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PRINCIPLES
OF FARM
PRACTICE

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RURAL EDUCATION SERIES

Edited by HAROLD W. FOGHT

PRESIDENT SOUTH DAKOTA TEACHERS COLLEGE

PRINCIPLES OF FARM PRACTICE

BY

BENJAMIN MARSHALL DAVIS

TEACHERS COLLEGE, MIAMI UNIVERSITY

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"SCHOOL AND HOME EXERCISES IN ELEMENTARY AGRICULTURE"

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PREFACE

For several years the author has been giving a survey course in agriculture for teachers and prospective teachers attending the summer session of Miami University. Many of these students, who were teachers of agriculture, have expressed a wish that the contents of the course be assembled and organized into a textbook adapted for use in the problem method of instruction.

An attempt was made to organize the material of this course around the farm as the unifying center. It was then submitted to trial in both regular and Smith-Hughes courses in high schools. The results of this test seemed to justify making the material thus organized available for instruction in the form presented in this book.

The author spent some time visiting high schools of Massachusetts where agriculture was being taught by the project method. Through the courtesy of Dr. Rufus W. Stimson, Director of the Massachusetts Agricultural Education Service, the author was able to see many of the projects in actual operation and to study the plans from which they were developed.

He also visited the agricultural colleges of many of the great farming states to inspect the work of training teachers for agricultural instruction. At this time he came into contact with a number of men interested in problems of agricultural education and with specialists in various scientific aspects of agriculture.

Mention is made of this fact in acknowledgement to those men for their contribution, though made unconsciously, to the preparation of this book. The field of agriculture is too large for one person always to be sure of his ground even in an elementary textbook. For this reason the author feels greatly indebted to

those who have helped give authority to much that appears in the following pages.

Particular reference should be made to Mrs. Mildred Douthitt Hiers, Mr. Charles Stephenson, and Mr. Clyde Hisson for advice and suggestions as to arrangement of subject matter from the teaching standpoint, and to Mr. Hisson, especially, for trying out the material thus arranged in a Smith-Hughes high school; to Miss Grace Kiernan for compiling index and reading proof; to Professor John V. Ankeney, of the University of Missouri, for reading the manuscript and for several illustrations; to Professor Bruce Fink, of Miami University, for critical reading of Chapters I, XIV and XV; to Professor T. L. Harris, of the University of West Virginia, for suggestions in preparation of Chapters XXVIII, XIX and XXX; to Dean Alfred Vivian, of the Agricultural College of Ohio State University, for comments on correct theories and practices relating to soil fertility and use of fertilizers; to Professor G. I. Christie, Director of the Agricultural Experiment Station, Purdue University, and to members of the staff, for many helpful suggestions and for reading the proof of the entire book; to Mrs. Emma Johnson Davis, wife of the author, for her great help in preparing the manuscript for publication and in reading the proof sheets.

Acknowledgement is given in the description of the figures as they appear in the text for those not made by the author or under his direction.

EDITOR'S INTRODUCTION

Principles of Farm Practice is written with the fundamental fact in mind that Agriculture teaching, like agricultural life, must be *lived* from day to day. Instruction in theory and the accumulation of facts are of little value in themselves. The textbook and teaching process that make the things taught part of the student's life, because of logical arrangement and practical application to every day affairs, are alone worth while. Such it is hoped, the present book will prove to be.

In teaching such a primary subject as agriculture, it is well to keep in mind that food, clothing and shelter come first in the list of human wants. Until they are provided the people, either savage or civilized, will pay little attention to the other desirable things of life. If modern agricultural people, therefore, are to live well rounded lives they must first of all be put in a position to make a good living out of the land. In the United States about seventy-five percent of the nation's wealth comes immediately out of the land in one form or another. The farmers are the greatest wealth producers we have, although not the greatest wealth keepers; for, under the present system of agricultural organization the farmers are able to keep only a small part of this wealth for themselves. The schools must, accordingly, teach new things, not alone in agricultural production — acre by acre, but also in how to prepare products for market and how to market them.

This book accordingly aims to help the children to become better and more scientific farm folk than those who have gone before them; but most of all it aims to help them to live happy, contented lives in the open country, in fullest harmony with the nature environment round about them. It is not enough to instruct in agricultural objects and practices; the educational and spiritual views of agricultural life are fully as essential. All of these are given careful consideration in the book.

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AUTHOR'S INTRODUCTION—TO THE TEACHER

THE successful teacher of agriculture has in mind the transfer of what he teaches into actual practice. His ultimate aim is not so much to present information about farming as it is to contribute something toward better and more profitable farming, the essential basis for a better and more attractive rural life. With such an aim his problem is by no means an easy one. "Profitable farming," says former Secretary Meredith of the United States Department of Agriculture, "depends upon three things: ample production, minimum cost, and adequate prices." — Referring to production he says:

"Ample production at minimum cost involves more efficient methods and economical operations. Factors in this are better utilization of the soil, more intelligent use of fertilizers, the use of better seed, the growing of more productive strains and varieties, better methods of preventing soil erosion, more effective methods of combating insect pests, plant and animal diseases, the production of more and better grades of live stock, better utilization of forage and roughage and waste materials on the farms, better maintenance of soil fertility by conserving soil moisture and manure, and a greater use of legumes in rotations and as companion or intertilled crops; the greater use of machinery and practical mechanical power on farms.

"The problem of securing for the farmer prices which will enable him to maintain production is a more difficult one. Attention must be given to better and more economical methods of grading, storing, marketing, and distributing farm products."

To these factors two others may be added: that of management which is necessary to correlate the various farm enterprises into a well-planned system; and that of adequate business accounting which must accompany efficient management.

It is difficult to find a basis of organization, or a principle of unity, to bind this large and diverse array of subject matter into a teaching whole. It cannot be found by considering agriculture as a science, although much of it is founded upon several sciences; for agriculture involves the art of farming as well as business methods. It seems necessary; therefore, to look to the successfully operated farm itself to find some means of unifying our subject for the purpose of instruction. From this source we draw two important conclusions in regard to successful farming: One is the characteristic of permanency that tends to conserve the resources of the land; the other, the close relationship between principle and practice observed in the various farm operations.

The late Professor Cyril G. Hopkins of the University of Illinois was fond of using the expression "permanent agriculture" when he referred to the objective of American farming. He had in mind not only the present farmer but also the future farmer. He thought not only of the individual farm but of all the farms in the country. He had in mind stability of farming as a national asset, as contrasted with the exploitation of naturally fertile land so much practiced today. He regarded the farm as an important unit in the conservation of our natural resources.

This idea of conservation, in the sense of permanent agriculture, if kept in mind when dealing with the various aspects of farming will help to give unity to the subject and to bind together many of the diverse elements that must be considered in teaching agriculture.

Furthermore, it is not easy to isolate principle from practice in farming. In actual farming the two are closely related. This fact has suggested the title of the book. It has influenced the development of the subject with the farm itself as the organizing center. It has enabled the author to eliminate much agricultural information which, though interesting, has little direct application in real practice, such as descriptions of insects and their classification, the history of breeds of live-stock, the detailed discussion of varieties of farm plants, geological formation of the soil, etc. This

plan was followed to enable the pupil to keep the farm and its operation prominently in view.

Another reason for recognizing the close relation of principle and practice in a textbook on agriculture is found in the present tendency to use the problem method and home projects in teaching.

It is the hope of the author that the matter presented in this book may be helpful to teachers who follow either or both of these types of instruction. In this connection it seems worth while to point out briefly the large aspects of the subject as they appear as a series of problems, one developing from another.

Starting with the plant — since all kinds of farming are based directly or indirectly upon plant products — it appears that we need to know how the plant itself lives and grows in order to help it live and grow. Such an inquiry leads to the conclusion that whatever help is given must be applied largely through the soil.

This suggests the soil as the next subject of study. What is the soil? Of what is it made? How does it hold water, air, and other substances needed by the plant in its growth? What substances in the form of fertilizers or soil amendments may be added to make the soil more productive? How may the various facts about the soil and its relation to plants be applied in soil management?

A knowledge of the soil and of how to manage it is needed for an intelligent production of crops. But crop production depends upon other factors besides the soil. What are the principles applying generally to all crop production? What are the special requirements for the production of common crops, such as corn, small grains, forage crops, and miscellaneous crops, and for the care and management of the farm garden and the farm orchard?

How may plants be improved to increase crop production? How may crops be protected from things that interfere with production, as weeds, plant diseases, and insects?

When a crop is produced what shall be done with it? Shall it be sold for cash or fed to farm animals? Shall farm animals be kept; if so, how shall they be cared for? What breeds shall be

kept or raised on the farm? If beef cattle, what breeds are desirable, and how shall they be handled? If milk is to be produced as a chief farm enterprise, what breeds of dairy cattle shall be used? What special care shall be taken in feeding and care of the herd; and what practice shall be observed in handling milk? If sheep or hogs are to be raised, questions of breed, feeding, shelter and care are important.

How shall all of the farm operations be correlated and the farm managed in an efficient manner? What accounts shall be kept in order to give necessary business information? What sort of a home shall the farmer have? What things are essential in making his home convenient, comfortable, and attractive?

Finally, what relationships shall the farmer have with his neighbors? What place shall he take with his fellow men in his community? What can he do to make his community a better place in which to live? What can he do in coöperation with others to make effective the various agencies of the open country that touch the lives of rural people, as farmers' clubs, the school, the church, and the recreation center?

Each of these questions or problems resolves itself into smaller ones. The larger ones are presented as a rule in single chapters, the smaller ones are indicated in paragraphs. The form of assignment of the particular problem is left to the teacher, but the subject is indicated by chapter and paragraph headings.

If a one-year or half-year course in high school, or a survey course in a Smith-Hughes high school is given, the order of the subject matter in the book may be followed. If home projects are developed, the particular parts of the book pertaining to the project may be used.

Although written primarily as a textbook it is the hope of the author that the material presented will not be limited to this field; but that it may prove worthwhile to the reader who is interested in rural life, and may be of practical service to those actually engaged in farming.

Further information on any subject in the book may be obtained

from the references cited in the Appendix. Here also will be found tables of digestible nutrients, and other data useful for instruction.

The author has departed from the usual custom of placing questions and exercises at the end of the chapters. A careful inquiry into the matter has seemed to indicate that neither questions nor exercises are much used. Most teachers prefer to formulate their own questions and topics, and to prepare their own laboratory exercises, or to use prepared exercises in which are fuller directions for work than can be given in a textbook.

BENJAMIN MARSHALL DAVIS.

OXFORD, OHIO,
February 1, 1922

PRINCIPLES OF FARM PRACTICE

CHAPTER I

WHAT WE NEED TO KNOW ABOUT PLANTS TO HELP THEM GROW

Plants, the basis of agriculture. — Plants are the foundation of all agriculture either directly when they supply food, clothing, or some other human need, or indirectly when they furnish feed for domestic animals. Since plants are really the basis of agricultural production, we must, first of all, in a study of agriculture consider some of the main facts about how plants live.

Plants are living beings. — That plants have life is a fact that needs to be repeated though it may be known to all who read these lines. It seems necessary to emphasize this because we habitually think of the word "living" as meaning to move around and behave like animals. As a matter of fact, plants are as much alive as animals. In order to live, they require essentially the same things as animals do; but they get these things in an entirely different way. The most important of these requirements are food, water, and air.

How plants get food. — The green plants make their own food from raw materials obtained from air, soil, and water. The basic food material made by the plant is starch or a starch-like substance. Starch is composed of three elements: carbon, oxygen, and hydrogen. The carbon and oxygen come

from a compound always present in the air, known as carbon dioxide, and the hydrogen from water. The starch-making process goes on in the green part of the plant, mostly in the leaves. But the work of starch-making from carbon dioxide and water requires power, or energy. This power comes from sunlight. Here we have an explanation of the fact that green plants thrive only in the presence of sunlight.

With starch-like substances thus formed as a basis, other food materials are made. For example, an important food known as protein is formed by using the elements composing the starch-like compounds made by the leaves, and nitrogen which is brought to the plant in substances dissolved in soil water. Besides nitrogen, a number of other chemical elements obtained from materials dissolved in soil water seem to be necessary for food-making in the plant. The most important of these, from an agricultural standpoint, are phosphorus and potassium.

Why plants need water. — That plants need water is shown by the fact that they soon die when deprived of water. A leading authority on plant life says that the greatest thing influencing plant growth is water. It is used by the plant in several ways. Its part in supplying the raw material for starch-making and in bringing to the plant several elements from the soil, as nitrogen, phosphorus, and potassium, has been mentioned. In addition, water helps to make the plant rigid; it composes most of the sap, transfers food materials from place to place in the plant, and assists in the control of temperature.

Water passes through healthy, vigorous plants in a constant stream, entering through the roots and escaping in the form of watery vapor through the leaves. A large amount of water is thus used by a plant during the growing season. It

is estimated that for every pound of dry matter produced by common cultivated crops an average of about 300 pounds of water must pass through the plants. It has been found that a

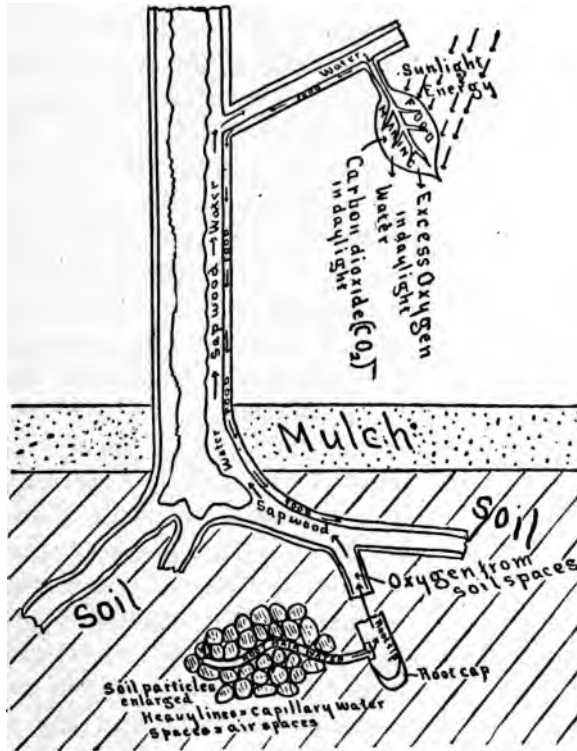


Diagram of a plant showing its relations to the soil, air, and water.

corn plant may lose nine pounds of water in eight and one-half hours. At this rate an acre of corn would lose forty-eight tons of water — an amount equivalent to one-half inch rainfall in the given time.

How plants get water. — If the roots of a young radish plant which has been developed by placing seed between two moist pieces of paper are examined, they



Diagram of root-hair much enlarged.

A. Cell or root from which root-hair is an outgrowth.

B. Root-hair.

C. Soil particle.

D. Film of water around soil particle.

Arrows show path of water through root-hair.

will be found to be covered with fine hairs. These hairs are called root-hairs. They are the absorbing organs of the roots. The roots themselves absorb little water. They serve to hold the plant in place. They also furnish surface for the development and distribution of root-hairs, in much the same way that twigs and branches of a tree afford surface for the development and distribution of the leaves. All the roots of a plant taken together are known as a root-system. As roots grow in length new root-hairs appear near the root-ends, while the root-hairs farthest away from the ends shrivel up and disappear. Thousands of little roots of a vigorously growing plant push their way into all parts of the upper layers of the soil, where they develop root-hairs for the absorption of water. In this way, much of the capillary water in the region of root growth is reached and supplied to the plant.

The extent of the root-system of a plant can be realized only by carefully measuring or estimating the total length of all the roots. It has been estimated that if all the roots of a nearly mature corn plant were placed end to end they would extend about one thousand feet, and that those of certain

squash plants would extend fifteen miles. The tendency of a root-system to reach into all parts of the soil near its surface is an important fact to remember. Thus, when the soil between rows of plants, like corn, is cultivated deeply, especially late in the growing season, many feet of small roots will be destroyed.

Root-systems are of two kinds; those having a central root with smaller roots radiating from it, and those having a number of roots of nearly uniform size extending from the part of the plant lying just beneath the surface of the soil. The former is called tap-root and is illustrated by the roots of such plants as the common clover; the latter are fibrous roots, illustrated by roots of such plants as common grasses. Tap-rooted plants are as a rule deeper growing than those having fibrous roots. This fact is sometimes of practical value in selecting a crop for very shallow soils, or for a rotation between shallow and deep-rooted plants.

How root-hairs take water from the soil. — Root-hairs have been referred to as the absorbing organs of the root. The way in which these hairs are able to absorb water from the soil may be illustrated by a simple experiment. If a bladder with a glass tube securely fastened into its neck is filled with a solution of sugar and then immersed in water with the tube above, the solution will begin in a short time to rise in the tube. This action is known as osmosis. It always takes place when two liquids of different

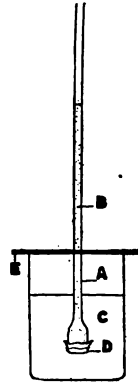


Diagram of simple apparatus for demonstrating osmosis.

- A. Tube.
- B. Sugar solution within tube.
- C. Water
- D. Membrane — lima bean skin — separating sugar solution from water.
- E. Cardboard support for tube.

densities, like water and sugar solution, are separated by a membrane through which water may freely pass. The water flows toward the liquid of the greater density, as in the above instance where it enters the bladder containing the sugar solution, or denser liquid, causing it to rise in the tube. The root-hair may be regarded as a small sac filled with a liquid somewhat denser than water. When the root-hair comes in contact with soil water some of the water passes into the root-hair just as water would enter a bladder filled with sugar solution. The water then proceeds from the root-hair into the root, and thence into the various parts of the plant.

Plants need air. — If a plant is deprived of air it soon dies. Not only does the air furnish carbon dioxide for the starch-making, but it also supplies oxygen in much the same way as is done in our own bodies. Oxygen is needed by all parts of the plant all the time. The parts of the plant above ground are surrounded by air and have air currents freely moving among them, so that they are at all times abundantly supplied with oxygen. The roots, on the other hand, being below ground and having only a small supply of air, may fail to get sufficient oxygen or may fail to have the supply renewed often enough to remove injurious gases as they accumulate in the soil spaces. An example of the effect of insufficient air on the growth of plants may be seen in the low wet spots in a field where some crop such as corn is growing. Plants in these wet spots are generally undeveloped and weak, and often die. This is because the water with which the soil is saturated has cut off the air supply from the roots, thus depriving them of oxygen.

How to help plants grow. — We have seen that plants require sunlight, air, water, and certain substances dissolved

in soil water. Our problem is to make conditions as favorable as possible for plants to meet these needs. A study of them will show that we have little or no control over sunshine and the air above ground. The chief way for us to help the plant therefore is through the soil. By means of various farm operations on the soil it is possible to control, to a considerable extent, the water supply and the air needed by the roots, and to furnish material containing such chemical elements as nitrogen, phosphorus, and potassium, in accordance with the needs of the plant.

This fact suggests the soil as the most appropriate subject to consider next in our study of agriculture. It is so important that we must study it in detail. Especially should we know what it is and how it is related to water supply, to air, and to plant food.

CHAPTER II

THE SOIL

IN the preceding chapter attention was called to the fact that some of the needs of the plant, such as sunshine, were beyond our control; while others — relating to the work of the roots — could be controlled through the soil, by making conditions more favorable. The effect of soil condition upon the entire plant is recognized by everyone who is familiar with growing plants. When the condition is poor, as in hard, dry soil, the effect is seen upon the entire plant. The roots, in such cases, are unable to do their work well. Consequently, the whole plant suffers. On the other hand, when the condition is good, as in granular, moist soil, the whole plant is well-developed and vigorous. The roots have access to air and are able to remove readily from the soil the water and material in solution needed for the growth of the entire plant.

Since so much in plant production depends upon the soil, it is necessary to understand the most important facts concerning it — what soil is, where it comes from, and the different kinds of soil.

What soil is. — By soil is generally meant the loose top-covering of the earth. If a small portion of this substance be placed in a bottle of water, well shaken and then allowed to settle, it will be seen to be made up of particles of different sizes. The larger particles will be found at the bottom, smaller ones next, and so on to the very fine particles that

remain for a while in suspension. Some small pieces of dark material will probably be noticed floating on the surface of the water. The larger particles are sand; the fine particles, silt; the very fine particles, clay; the floating bits of dark material, organic matter, or humus. Sand, silt, and clay are rock particles, differing mainly in size. Organic matter, or humus, is the remains of decayed plants or animals.

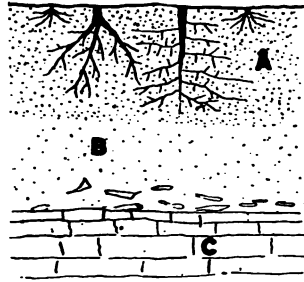


Diagram illustrating relation of soil to sub-soil.

A. Soil. B. Sub-soil.
C. Underlying rocks.

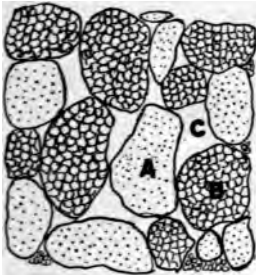


Diagram of soil particles enlarged.

A. Sand.
B. Granule — composed of very fine particles.
C. Air space.

Where soil comes from. — A long time ago the upper surface of the earth was solid rock, and in some places this condition still exists. By action of wind and rain, heat and cold, plants and animals, and other agencies, many of the rocks have been broken into particles small enough to be washed away by water or blown about by winds. Through a long period of thousands of years these processes have been going on. The rocks on higher places like mountains and hills have been broken up, and the small fragments have been carried to lower levels by water and wind, where they were left to form the soil as we see it. In the meantime, plants have grown and died and their remains have become mixed with the rock particles. This fact accounts for the presence of organic matter, or humus, in the soil.

Loss of soil by the action of water. — The same processes that made the soil are continuing today. Material from higher levels is constantly being removed by water to lower levels. This not only applies to the wearing away of rocks, but to that of the soil itself. One has only to observe the effect of a rain to see how readily the soil is washed from a hillside. The soil particles are carried by the smaller streams into the larger ones, and so on, until finally some are swept



An illustration of effect of erosion on a field.
(U.S. Dept. of Agriculture.)

into the ocean. But all along particles are left by the water; by the slow waters in bends, on level stretches, and at the edges of the streams, especially as the waters of the streams get lower and the currents less swift.

If the bottom land which has recently been covered with the water from an overflow of a stream is examined, it will be seen to be covered with fine sand and silt left there by the receding waters. This deposit has come from the land of

higher levels. The total amount of soil thus carried away is very great. It is claimed that if all the soil particles carried by the waters of the Mississippi River in one year were made into a solid rectangular block, it would cover one square mile and be 268 feet high. The amount of soil carried away by water varies with the slope of the land; the steeper the slope, the swifter the water current, and therefore the greater the quantity of soil material carried away. In hilly lands the loss of soil from the uplands is considerable, so much, indeed, that measures need to be taken to reduce the loss.

Kinds of soil. — The size of the particles which make up the soil varies greatly. In some places most of the particles are sand, as in a sandy soil. In others, clay particles are most abundant, as in clay soil. Sometimes particles of clay and silt make up about half and sand the other half. Such soil is called a loam. If the mixture contains somewhat more fine particles than sand, the soil is known as a clay loam; but if more sand than silt and clay, it is called a sandy loam. These names, sandy, clay, loam, clay loam and sandy loam, are in common use in describing soils.

We should now turn back and read again the first paragraph of this chapter and notice especially the last sentence in the paragraph. Rock particles alone, although they make up the soil mass, do not constitute a fertile soil. Air, water, and material for plant food are equally essential for plant growth. For this reason each of these should be considered in its relation to the soil, on the one hand, and to the plant on the other. In the next few chapters we shall try to learn something more about these relations.

CHAPTER III

SOIL WATER AND SOIL AIR

WATER IN THE SOIL

Why water is needed. — The importance of water for plant use has already been intimated in Chapter I. It is not only directly useful in the various ways noted in that chapter, but it has indirect benefits upon plant life almost as great.

Water is a great solvent. That is, it has the power of changing substances from a solid condition to one known as a solution. A lump of sugar placed in a glass of water soon disappears as a solid. The sugar is held invisibly in some way by the water, for we know that water in which sugar is dissolved tastes sweet and when evaporated leaves a solid residue of sugar. This property of water — acting as a solvent — enables it to dissolve certain solid substances of the soil so that they may pass in solution into the plant, the only possible way for them to enter. The same property enables the water to carry dissolved material from place to place in the soil, as from the depths to the surface when the water moves upward.

Water also brings about changes in the position of the soil particles with reference to one another, making the soil in some instances granular, and in others more compact. This fact will be kept in mind as a further consideration of the action of water in the soil since it is an important one in connection with soil management.

Water has another property that is of importance in soil management. It has a large capacity for absorbing and retaining heat. This property is made use of in heating buildings by hot water systems. Water once heated remains hot for a long time, giving off heat slowly, but in sufficient quantities to keep the rooms of a building warm. Another illustration is found in the influence of large bodies of water,

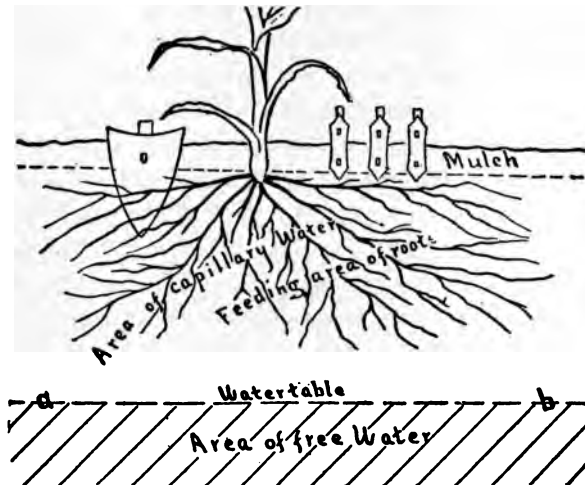


Diagram showing regions of capillary and free water. Note distribution of roots in area of capillary water.

such as the Great Lakes, in tempering climate, making the shore regions warmer in winter and cooler in summer.

Water in the soil influences its temperature — an important matter in crop production, especially in early spring when heat is needed to start plants to growing. Soils having a large capacity for holding water are called cold soils, because when filled with water which takes up heat slowly they remain cold long after soils having less capacity for holding

water have become warm. Heavy clay is an example of a cold soil; it is not the clay but the water held by the clay that makes it slow to heat. Sandy soil, on the other hand, which holds but little water, is regarded as a warm soil.

Another use for water in the soil is that it meets the need for moisture of certain microscopic plants, chiefly bacteria, that are always present in fertile soils. These organisms need water quite as much as other forms of life.

How water is held by the soil. — In order to understand how the soil holds water, we must keep in mind the fact that it is largely made up of particles of rock. These particles are irregular in shape and size, so that spaces are left between them. The arrangement may be suggested by thinking of a number of rocks and bricks thrown loosely together. Here spaces of various sizes and shapes occur among the rocks and bricks just as they occur among soil particles, differing only in size. When these spaces are filled with water, the water is known as free water. When water appears at the surface of the soil or at lower levels, as when a hole in the ground becomes filled with water from adjoining soil spaces, it furnishes an example of free water.

When water clings to the surface of soil particles and is held in the sharp angles between them, but does not occupy the spaces, it is known as film or capillary water. If a pencil is dipped in water, the part coming in contact with water will become wet. Here the solid substance of the pencil attracts and holds a thin layer of water on its surface. It is in a similar way that solid particles of the soil hold films of water on their surfaces. Capillary water is important because it is almost exclusively the form of water used by the plant. When the spaces of the soil in which the root of a plant is growing are filled with water, the air supply is cut

off from the roots and the plant suffers. It is largely for this reason that the water of the soil in the region of the roots should be capillary or film water, and not free water.

Amount of water held by the soil. — We have seen that roots of plants rely on root-hairs to secure water and that the water must be in the form of capillary or film water. The quantity of capillary water held by the soil is important, for the amount that can be removed by the plant will depend upon the supply within easy reach of the roots.

Soils differ greatly in their capacity to hold capillary water, due to differences in the size of soil particles. If a piece of solid substance one cubic inch in size is put in water and then removed, a certain amount of water will adhere to each of its six sides or surfaces. If the cube be cut in half, it will present two additional surfaces capable of holding a layer of water. By dividing the cube its power for holding film water is increased, although the amount of solid material remains the same. Each division adds more surface; the greater the number of divisions, the greater the total surface provided for contact with water. The total surface of all the particles of a cubic foot of sandy loam has been estimated at 1.39 acres; of clay, 3.54 acres.

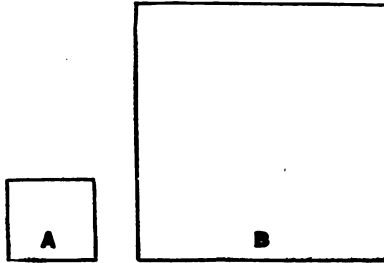


Diagram showing relative amount of surface exposed by sand and clay.

A. Sand. B. Clay.

A certain mass of coarse particles, such as sand, will have less total surface than a similar mass of silt or clay which consists of finer particles. Consequently, sand will hold less film water than either silt or clay. This fact is easily demon-

strated by filling two tin cans of the same size, having perforated bottoms, one with dry sand, the other with dry, clay soil. After weighing, each can is saturated with water, and then allowed to drain. The water held in each can after draining will be mostly film water. When weighed again, the amount of film water in each may be determined by subtracting the first weight from the second. It will be found that the clay or fine soil has held more film water than the coarse soil. Sandy soil has a low water-holding capacity compared with clay or clay loam; its capacity may be increased by adding organic matter, such as manure, which retains a great deal of water.

Clay and clay loam, because of the fineness of their particles, retain relatively a large amount of film water, but they have a tendency to bake and become hard and cloddy after a rain. This tendency makes such soils difficult to handle. They are sometimes called heavy soils, not because they are really heavy but because they are hard to work. This is a serious difficulty, but one that may be overcome, in a large measure, by modifying the soil structure in such a way as to make it retain its capacity to hold water and, at the same time, make it more easily handled.

How water moves downward in the soil. — When rain falls or snow melts the water has a tendency to move downward or percolate through the soil. This movement proceeds until the level of the free water below, known as the water table, is reached. As the free water accumulates, the water table rises until finally the upper surface of the soil is reached. The soil is then saturated, all the spaces being filled with water. When more rain falls, the water either runs off or stands in puddles. This condition frequently occurs in early spring after the spring rains or melting of the winter snows. As

the water near the surface evaporates or drains off, the water table is lowered leaving in the upper part of the soil only capillary water, the presence of which is favorable for seed germination and plant growth.

The free water acts as a reservoir to be used later by the plants in the growing season when there may be less rainfall. It becomes important, therefore, to get a sufficient supply of free water into the soil during the time of heavy rains. We need to know in this connection something about how water moves downward in the soil, in order that measures may be taken to secure the greatest benefits from water that reaches the soil.

The downward movement of water through the soil is caused by gravity. The rate, or rapidity of movement, depends upon the size of the soil particles. When one lamp chimney is filled with sand and another with clay, and water poured into each, it will be noticed that the water runs through the sand very quickly but through the clay very slowly. The rate of percolation in heavy soils is so slow that when rain falls on them, much of the water runs off instead of entering. This run-off not only results in the loss of water that might otherwise be stored up in the soil for future use, but takes with it some of the soil, another considerable loss.

Sandy soils need no attention in this respect, since the water readily enters and rapidly sinks to lower levels.

How water moves upward. — The oil in a lamp constantly moves along the wick and up to the flame. In a similar way water passes through a column of soil. This may be illustrated by filling a lamp chimney with sand and placing one end in a glass of water. Immediately the water will begin to rise in the sand, soon reaching the top. This action is known as capillarity. The soil particles or grains of sand nearest the

water draw films of water around them; these films extend to the next layer of particles, and so on until the surface is reached. If the lamp chimney is filled with clay, the water will pass upward very slowly, requiring perhaps several hours to reach the top. The rate of capillary rise evidently de-

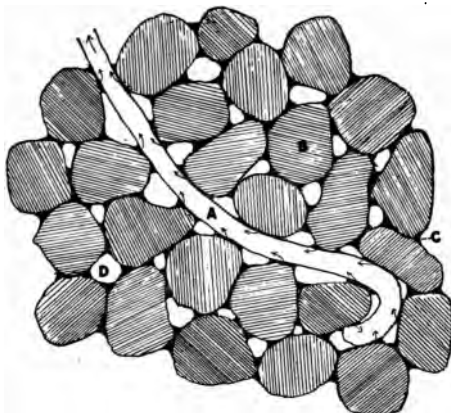


Diagram showing the relations of soil particles and water film to a root-hair.

- A. Root-hair. B. Soil particle.
C. Film of water—thickened at angles.
D. Air space.
Arrows show direction that water takes.

pends upon the size of the soil particles; the smaller the particles, the slower the rate.

The effect of the different sized particles on capillary action is important in another way. If, instead of short lamp chimneys, long glass tubes filled with sand and clay are used, it will be seen that when water reaches a certain height in the sand it will rise but

little higher, whereas in the clay it will continue to rise slowly for a distance of several feet. In other words, the lifting power of sand through capillarity is much less than that of clay. Clay soils are, therefore, able to draw water from greater depths than sandy soils, and consequently are less affected by dry weather than sandy soils, provided there is a supply of free water below. The great power of clay soils of lifting water by a capillary pull is somewhat offset by the slowness of its action. The same means suggested

for the improvement of such soils by securing more rapid percolation will also, to a certain extent, increase the rate of capillary action.

How to prevent the loss of soil water. — There are two sources of loss of soil water. One is the run-off of water that fails to enter the soil; the other is through evaporation of water at the surface.

Loss of water through run-off may be reduced in two ways: improving the structure of heavy soils by securing granulation through the use of lime, organic matter, tillage, and drainage; or modifying the surface in such a way that it will be difficult for water to run off — by fall plowing, making the furrows at right angles to the slope of the land.

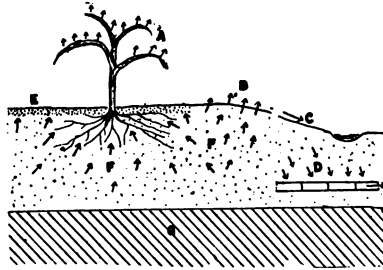


Diagram showing various losses of water.

- A. Through plant and out at leaves. Transpiration.
- B. Evaporation from the surface of the soil.
- C. Run-off.
- D. Percolation. Drainage.
- E. Mulch preventing loss of water.
- F. Area of capillary water.
- G. Area of free water.

Loss of water through evaporation is shown by the drying of the upper layer of the soil. The extent of this loss may be measured roughly by weighing a pan of damp soil, leaving it in the open air for a few days and then weighing it again. The difference in the two weights represents the loss by evaporation for this period. It is estimated that about one-half of the water reaching the soil by rainfall is lost through evaporation, unless some means is taken to prevent it.

Since most of the water lost in this way is capillary water, the form absorbed by the root-hairs of plants, it is desirable

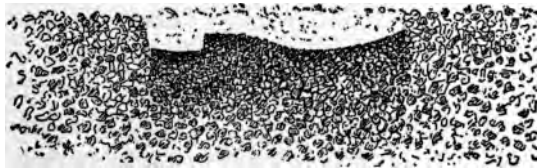
to check the loss by some means. It will be noticed that the soil under a board or a similar covering is often damp, although the adjacent soil may appear quite dry. This suggests the use of some cover on the soil to prevent a loss of water. For such purpose, except in protecting certain valuable garden crops, boards are not practical because of the expense and labor. Straw is sometimes successfully used as a covering. But another much simpler and less expensive method is to stir, or otherwise pulverize, the upper two or three inches of the soil until it is finely divided. The finely-divided upper layer of soil serves the same purpose as a board or other covering and effectually checks the loss of water through evaporation. Such a covering is called a soil mulch and is always used in the best farm practice.

How to make best use of a soil mulch. — There are a few things that should be kept in mind when using a soil mulch. First, the mulch should be as perfect as possible; that is, the part of the soil forming the mulch should be uniformly fine, without clods, but not fine enough to form a dust. Second, the mulch should be renewed from time to time, for the water is likely to ascend gradually from below through capillary attraction until the surface is reached and there evaporate. Third, the mulch is always destroyed by rain and therefore should be renewed after each rain.

The series of farm operations necessary to prepare the soil is not complete until a good mulch is formed. If a crop is a cultivated one, like corn, it will be necessary to renew the mulch from time to time. Incidentally, if a good mulch is secured and maintained, weeds, which also occasion loss of water, will be kept down.

How to bring water to the surface of the soil. — Sometimes the upper part of the soil becomes so dry that it does

not furnish a sufficient supply of water to germinate the seeds that have been planted. In such cases the soil particles are too far apart to allow capillary water to reach the seeds. Here the problem is how to restore the capillary action so as to bring water from below in sufficient quantities to secure germination. This may be accomplished by forcing together the particles near the surface, by the use of a roller or by similar means. The broad wheels of a corn planter following, as they do, the grains of corn dropped before them, serve to pack or firm the soil at each hill. This establishes the capillary current, bringing the water where it is needed for germi-



Effect of compacting soil. (Cornell Agr. Exp. Station.)

nation. As soon as the firming of the soil has served its purpose, that is, when the seeds have germinated, the mulch should be restored; otherwise there will be a loss of water by evaporation which will offset the gain of quick germination.

How water may be controlled by drainage. — Drainage is an important means of controlling soil water, especially in heavy soils. The condition of the soil which often occurs in early spring has already been described. Here the free water interferes with working the soil by making it difficult or impossible to handle. It also interferes with the early development of the plants by keeping the soil cold, thereby preventing the rapid growth of the young plants as well as

restricting their roots to a region near the surface above the water table. If the soil, in such condition, is undrained, there is no way for the surplus water to escape except through evaporation. But evaporation requires heat; consequently, the heat which otherwise might be used in warming the soil is used to evaporate water. Furthermore, the water table during the process is lowered so slowly that the roots of the

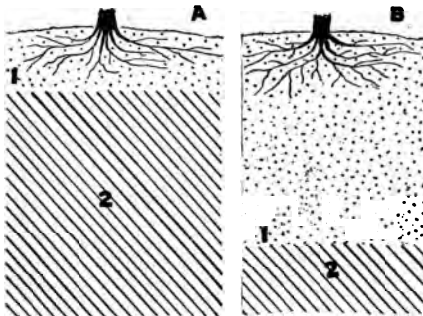


Diagram of section of undrained soil.

A. Early in season. Roots are kept near the surface.

B. Late in season. Plant suffers from drought because of shallow roots not being able to reach area of capillary water.

young plants are kept near the surface of the ground, because they will not grow to any extent in the free water below the water table. Later in the season, the water table drops to lower levels, but a gap is left between the free water below and the feeding area of the roots above. The distance is often too great for a supply of water to be lifted by capillary action

to the region of the roots. Hence, plants in undrained soils frequently suffer from drought.

Now, if the land is well drained, the water table is soon lowered by the removal of the surplus water through drainage instead of through evaporation. Thus the heat, which in undrained land must be used to lower the water table by evaporation, is saved. At the same time, the water table is quickly lowered and plants are able to send their roots deeper into the soil. When the dry weather of the later season comes,

the roots may then be deep enough to receive plenty of water from below through capillary action. Hence, we have the apparent paradox of supplying more water to plants by removing part of it.

Soil management. — Proper soil management with reference to water supply and control is difficult at best. It can be accomplished only by making intelligent use of the facts concerning soil water that have been presented in this chapter. Further details of soil management will be considered in a chapter devoted to the subject.

AIR IN THE SOIL

What soil air is. — Atmospheric air contains nearly 21 per cent of oxygen, 79 per cent of nitrogen, and .04 per cent of carbon dioxide. Soil air differs from

the free air above, in the respect that it has less oxygen and from 5 to 75 times as much carbon dioxide. Plant roots and decaying organic matter produce enough carbon dioxide to account for this difference.

How air is held in the soil. — The soil spaces which are not occupied by water are filled with air. The presence of air in the soil may be shown by pouring water into a vessel containing soil. When the water enters, bubbles of air will

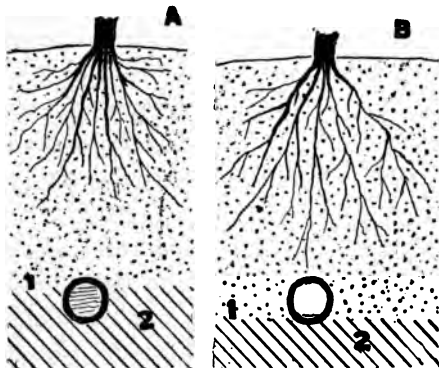


Diagram of section of drained soil.

A. Early in season. Free water removed from upper level permitting roots to grow deeper.

B. Late in season. Feeding area of roots within region of capillary water.

be forced out by the water. In a similar way the amount of air in a certain soil mass may be determined by measuring the volume of water needed to crowd out or replace the air. Since the water takes the place of the air the volume of water used represents the volume of air present in the soil before the water was added.

The amount of air in the soil not always the same. — Since air is in the spaces between the soil particles, the amount of it will depend upon the size and number of these spaces and upon the degree to which they may be filled with water. The latter point is important, because the air in the upper part of the soil, where it is most needed, can be controlled to a certain extent by regulating the amount of free water.

Why there is a need for soil air. — Attention has been called to the fact that the roots need oxygen all the time just as much as other parts of the plant. In order to meet this need of oxygen the soil should be well aërated.

Soil aëration is important for other reasons. First, there are certain useful bacteria that help to make the soil more fertile. These bacteria need oxygen, and when the roots of plants are provided with oxygen, the bacteria are served at the same time. There are other bacteria that need nitrogen as well as oxygen. As the air is about four-fifths nitrogen which is thoroughly mixed with oxygen, there will always be a good supply of nitrogen in well-aërated soils.

Second, carbon dioxide always present in free air and more abundant in soil air is absorbed by the soil water, thus giving the water a greater solvent power than when pure. It is then able to dissolve more soil material which is useful to plants than it otherwise would. It is possible that too much carbon dioxide may prove injurious to the roots of the plants,

but this is not likely to occur, especially when the soil is well aërated.

How the air is supplied. — Any operation that will provide soil spaces, which allow air to enter the soil readily, will keep the soil well supplied with air. As a rule, sandy soils present no difficulty, because the large soil spaces between the particles allow air to enter freely. On the other hand, heavy soils, such as clay and clay loam, having small spaces between the particles, need some modification. By producing a granular condition in the upper part of the soil, the spaces will be enlarged enough to allow air an easier access. If good drainage is provided, the water passing into the drain will be replaced by air. Granulation and drainage are important for other reasons, some of which have been given; others will be considered later.

CHAPTER IV

PLANT FOOD AND SOIL FERTILITY

What plant food is. — While the plant really makes its own food from certain simple substances as was shown in Chapter I, the expression “plant food,” as commonly understood, refers especially to those substances that are taken from the soil and used by the plant. These are water and certain soluble compounds containing elements necessary to plant growth. Some of these elements are actually used to make food, and others though not used as food are quite as essential, as shown by the fact that plants will not grow without them. The following is the entire list of elements: nitrogen, phosphorus, potassium, calcium, chlorine, magnesium, iron, and sulfur.

The last four of the list are used in such small quantities that the natural supply in the soil is relatively abundant. But one or more of the first four — nitrogen, phosphorus, potassium, and calcium — may not be available in sufficient amounts to afford plants their best development. For this reason it will be worth while to consider them separately.

NITROGEN

Supply of nitrogen. — There are three sources for the supply of nitrogen in farm practice: the organic matter, or humus, found in naturally fertile soils, in crop residues, and in manure; the atmospheric nitrogen made available for

plant use by certain bacteria, chiefly those occurring on the roots of such crops as clover; certain products rich in nitrogen that are sold as commercial fertilizer.

Value of organic matter. — In the early days of farming the soil was treated as if it were inexhaustible; crops were taken off year after year without a thought of returning to the soil any equivalent of the plant food removed. As a consequence, the yield became less and less until finally the farms became unprofitable. They were rightly called "worn-out" farms and were often abandoned. Abandoned farms are still found in some parts of the Eastern States. One practice, which more than anything else brought about a decrease in yield, was the removal of the organic matter. This practice made farming hard for two reasons; it reduced granulation and the water-holding capacity of the soil, and depleted the store of nitrogen. Many worn-out farms have been brought back to fertility by being liberally supplied with organic matter.

Making the nitrogen of organic matter available for plant use. — The presence of bacteria in fertile soils has been referred to several times. Bacteria are very small plants, so small that the aid of a good microscope is necessary to see them at all. It would require many thousands in line to span an inch. But they make up for their small size by their great numbers. It is estimated that a cubic centimeter of rich soil will contain from 500,000 to 5,000,000.

Some of these bacteria are able to convert the complex and insoluble compounds of organic matter containing nitrogen into simple, soluble compounds of nitrogen, chiefly nitrates. Nitrates, being soluble, are readily absorbed by plants.

Bacterial action is required in order to make available for

plant use nitrogen and perhaps other food material found in humus, manure and crop residue, such as straw. The series of changes brought about by the action of bacteria on the content of organic matter is called nitrification. There are some conditions favorable to nitrification that should be understood. The presence of water and oxygen is essential. Any treatment of the soil that will secure plenty of water and oxygen in its upper surface will be favorable to nitrification.



A common example of how manure may lose much of its value as a fertilizer. (Indiana Agr. Exp. Station.)

It is also true that water and oxygen are essential for the best development of crops. Some of the methods of controlling the water supply and of aerating the soil have already been considered.

Source of organic matter on the farm. — The most common and most

valuable form of organic matter that accumulates on the farm is stable and barnyard manure. Straw, cornstalks, and other crop residue are also valuable. Certain heavy crops, such as rye and cowpeas, are sometimes grown as green manure, for the express purpose of adding organic matter to the soil.

Value of manure. — Barnyard and stable manure is not only rich in nitrogen, but also contains a considerable amount of phosphorus and potassium. The money value of these three elements alone is estimated at \$2.00 or more, per ton. The total value of the annual production of manure in the United States has been roughly estimated at \$800,000,000

and more than one-half of it said to be wasted. The presence of nitrogen, phosphorus, and potassium in manure does not represent its entire value. When mixed with soil, it increases the water-holding capacity if the soil is light, and promotes granulation if the soil is heavy. At the same time it brings into the soil countless bacteria that are useful in liberating or making available plant food, particularly nitrogen.

How to prevent loss of nitrogen from manure. —

Since manure is of so much value, all possible measures

should be taken to prevent its waste. In order to make clear a means of preventing or reducing the losses of nitrogen from manure we need first to consider what takes place in an

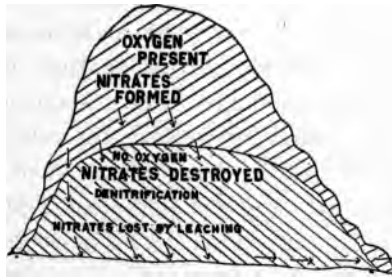


Diagram of a manure pile showing how nitrogen may be lost.

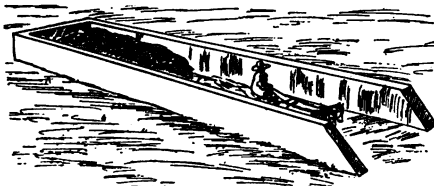


Diagram of a concrete pit for storing manure. If the pit is water-tight there will be little loss of plant food, especially if the manure is kept well packed.

ordinary pile of manure when it is left in the open. In such cases decay and putrefaction rapidly occur through the action of bacteria. Among the final results of this action is the change of nitrogen compounds into simpler ones

known as nitrates. Nitrates are quite soluble and are, therefore, easily washed away as the water from rains passes through the heap. Nitrates in the lower part of the pile that do not escape in this way may be broken up by other

kinds of bacteria into ammonia and free nitrogen which pass into the air as gases. Ammonia is often so plentiful around stables that it may be detected by its odor.

The loss of nitrogen may be greatly reduced if the formation of nitrates can be prevented. Since nitrates are formed by certain bacteria which must have oxygen, an easy method is suggested for preventing their formation; that is, to make conditions unfavorable by excluding air. This may be accomplished by making the pile as compact as possible, excluding the air by tramping or otherwise pressing the material together as it accumulates. The walls of the pile should be nearly perpendicular, so as to reduce the action of rain and avoid loss by leaching.

A better plan would be to keep the manure under cover. A practice frequently followed in England and sometimes in this country is a good one. The stables are provided with deep stalls furnished with plenty of straw for bedding. The straw absorbs the liquid wastes and is under cover, and as the manure accumulates it is also thoroughly packed by the tramping of the animals.

Another method of preventing the deterioration of manure is to spread it on the fields as rapidly as it accumulates. This practice is comparatively easy if manure spreaders are used. It is said that a manure spreader will pay for itself in less than two years by preventing loss of nitrogen and by saving labor. After the manure is spread upon the field the formation of nitrates is an advantage rather than a disadvantage, for they pass into the soil where they are needed as they are formed.

Use of legumes for supplying nitrogen. — Legumes are those plants which belong to the pea family. Some common examples are peas, beans, clover, alfalfa, and vetch. If one of these plants is dug up and its roots examined carefully,

they will be found swollen into knots in some places. These knots are called root nodules and are characteristic of legumes. Each nodule contains bacteria of a kind known as nitrogen-fixing bacteria. They have the power of using the free nitrogen of the soil-air and building it up or fixing it into simple nitrogen compounds, such as nitrates.

But the nodules do not always form on the roots of legumes.



Photograph of roots of red clover showing nodules of nitrogen-fixing bacteria. Nitrogen-fixing bacteria greatly enlarged. (Wisconsin Agr. Exp. Station.)

This may be the case when an attempt is made to grow the legumes on a soil where they have never been grown before. In such cases the soil must be inoculated.

By soil inoculation is meant the process of transferring to the soil nitrogen-fixing bacteria enough to start nodules on the roots of the young legumes. One method is to scatter over the field to be planted some of the soil taken from an-

other field, where the same or a similar kind of legume has been growing. For example, to establish alfalfa in a place where it has never grown before, soil should be taken from a field of vigorously growing alfalfa, and uniformly scattered over the new area to be planted, at the rate of about 160 pounds to the acre; or inoculating material may be obtained from a soil on which sweet clover is growing. Owing to the destructive action of the sun's rays on bacteria it is important to spread the inoculating material during a cloudy day and to work it into the soil immediately.

Another method is to treat the seed of a legume, before sowing, with a solution containing nitrogen-fixing bacteria. Material for this method of inoculation, together with detailed directions for use, may be obtained from a State Agricultural Experiment Station, or from a commercial firm recommended by the Station.

The use of legumes for maintaining soil fertility cannot be overestimated. They are also a valuable crop for feeding farm animals. On every farm a rotation should be established which will include a leguminous crop every few years, never more than five years apart. The selection of a particular legume may depend upon the use for which it is intended and upon its adaptability to climate and soil. In some places it may be clover; in others, alfalfa; in another, cow-peas or soy beans; the important thing is to include some kind of legume in a rotation.

Commercial fertilizers as a source of nitrogen. — If nitrogen cannot be maintained in the soil in the ways described, as a last resort it may be purchased in the form of a fertilizer; but it will be found more expensive than any other kind of commercial fertilizer. Therefore it should be supplied in other ways whenever possible. The use of nitrogen in the

form of a commercial fertilizer may be sometimes justified in spite of its expense. It may be used when nitrogen cannot be secured through the use of manure and rotation of crops; or when it is desirable to give a crop an especially good start, as corn in early spring, or wheat in the fall. In such case the nitrogen is added for its immediate effect. It is at once available for plant use; whereas, in early spring, the natural supply of available nitrogen is small due to the effect of cold on bacterial action; and in the fall, because the preceding crop has partially exhausted the supply. In such cases the supply of phosphorus and potassium may also be limited, and the use of a complete fertilizer — one containing all three elements — would be justified. But whether nitrogen is used alone or in a complete fertilizer, a light application is generally more profitable than a heavy one.

Nitrogen may be supplied from certain substances (called carriers) that contain it. Nitrate of soda, sulfate of ammonia, and dried blood are always safe to use and are really economical even though they may seem expensive, since they are readily available for plant use.

PHOSPHORUS

The supply of phosphorus. — There is a limited supply of phosphorus in most soils. A small amount occurs in manure and in other organic material, but not in sufficient quantities, as used in ordinary farm practice, to offset the amount removed by crops. It must be bought and added to the soil from time to time. Since it must be bought, economy in buying should be considered.

How to secure phosphorus. — The chief source of phosphorus is certain mineral deposits known as phosphate

rock; some is also supplied by the bones of animals. Bones are rich in phosphorus. Rich deposits of phosphate rock occur in several parts of the country, as in Utah, Tennessee, South Carolina, and Florida. These rocks may be finely ground and sold as rock phosphate; or, after being ground, may be treated with sulphuric acid, and the resulting product sold as acid phosphate. The distinction between ground-

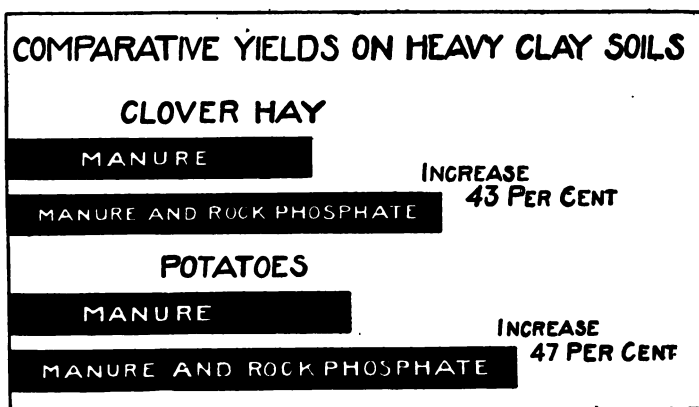


Chart showing increase in yield of wheat on heavy clay soil by use of manure and rock phosphate as compared with yield when manure alone was used. (Wisconsin Agr. Exp. Station.)

rock phosphate and acid phosphate must be clearly understood. Rock phosphate is insoluble and not immediately available for plant use. Acid phosphate, on the other hand, is soluble and therefore available at once for the plant to use. If quick results are desired from the use of a phosphate fertilizer, acid phosphate should be chosen.

When and how to use rock phosphate. — Ground phosphate rock has a market value of about one-third that of acid phosphate. Owing to this fact, it would seem advisable to

use the cheaper form, if its application secures favorable results compared with those obtained by the use of acid phosphate. As has been stated, the quick action due to solubility must not be expected of phosphate rock. There is a question whether the use of rock phosphate fertilizer is ever warranted. There is good authority for believing that its use under certain circumstances does give results equal, or nearly equal, to those obtained from acid phosphate and at less cost. It is supposed that rock phosphate becomes slowly available for plant use through the action of bacteria in the presence of an abundance of organic matter.

In practice, as manure accumulates, finely ground rock

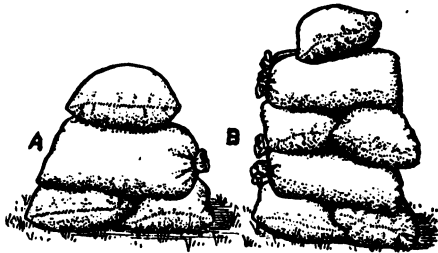


Diagram showing yield of potatoes. Manure and rock phosphate produced a yield 47 per cent greater than that of manure alone on equal areas. (Wisconsin Agr. Exp. Station.)

phosphate is mixed with it; later, when the mixture is applied to the land and plowed under, the rock phosphate becomes thoroughly incorporated with the soil along with the organic matter of the manure. If the soil is not already rich in lime, lime or limestone should also be liberally applied. The insoluble phosphate seems to be changed into a soluble form, though so slowly that the effect of the fertilizer does not begin to show much until the second season; but from this time on for a few years, it seems to have the same effect as acid phosphate. The slowness of action may not be a serious matter, for in good farm practice permanent fertility of the soil is of more importance than the results of one season.

Besides, in order to hasten matters acid phosphate may be applied as a phosphate fertilizer for the use of the first season's crop.

It has recently been suggested that the phosphoric acid of phosphate rock may be made available for plant use by mixing it with calcium sulfate, or land plaster. This claim seems to be supported by some experiments made by the Oregon State Agricultural Experiment Station. If this method should be proved successful by experiments in different parts of the country under a variety of soil and climatic conditions, it might become worth while in general farm practice. To be of practical value, however, the combined cost of the calcium sulfate and phosphate rock should be less than the cost of acid phosphate enough to yield an equivalent amount of phosphoric acid.

POTASSIUM

The supply of potassium. — Potassium occurs in soils usually in considerable abundance, except in very sandy and muck soils. Not much of it is available because it is insoluble. It seems to be demonstrated by recent experiments that insoluble potassium may be made available through a liberal supply of organic matter. It is a question whether this method of supplying potassium may be wholly relied upon to furnish all that is needed by crops. It may be worth trying however, for even if it should fail to render much potassium available, it will leave the soil improved because of the addition of organic matter.

Potassium occurs in large deposits in a few places in the world, the most extensive being found in Germany and in Alsace, France. Until recently most of our potash fertilizers

have been imported from Germany. During the Great War when importation was cut off, an increasing amount of potassium was supplied from a number of sources: among

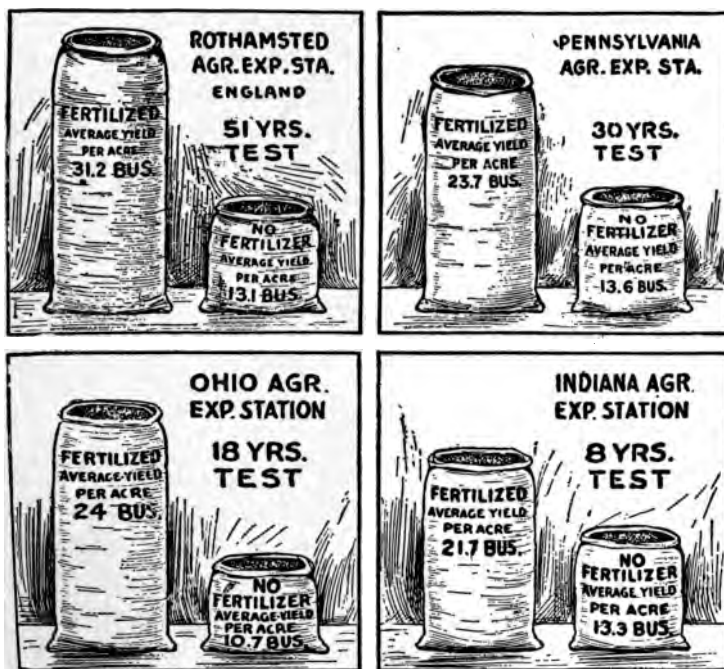


Diagram showing increase in yield of wheat where fertilizers were used as contrasted with yields on similar areas where no fertilizers were used. (Ohio State Agr. College.)

them, sea weed or kelp, found in great quantities in the Pacific Ocean; mineral deposits in old lake beds, as in Searles Lake, California; wood ashes; and the by-products of such industrial processes as the making of cement and washing of wool. It seems probable that, in time, a means will be found

in the United States to supply most of the potassium needed for our farms.

Potassium, as a commercial fertilizer, is usually supplied in the form of potassium chloride or muriate of potash, sulfate of potassium, and kainit. The first two contain about fifty per cent of potash; kainit, or mineral potash, contains from twelve to twenty per cent. The word potash is used by chemists to express the amount of potassium in a chemical analysis.

For certain special crops such as potatoes and tobacco which have large potash requirements, it is a good practice to apply some form of fertilizer containing potash. (The buying and use of commercial fertilizers will be considered in greater detail in the next chapter.)

CALCIUM

The supply of calcium. — Plants require but little calcium for their growth. The store of calcium in most soils is sufficient to supply the actual needs of the plant. The chief value to a soil of substances containing calcium, such as limestone or lime, is an indirect one — they neutralize soil acids. There are plants, such as legumes, which will not grow well in acid soils. There are other important effects of calcium (in the form of lime or limestone) on soils which will be discussed in the next chapter.

CHAPTER V

COMMERCIAL FERTILIZERS AND SOIL AMENDMENTS

COMMERCIAL FERTILIZERS

What is meant by commercial fertilizer. — The term commercial fertilizer has already been used several times in discussing plant food. It always refers to those substances containing nitrogen, phosphoric acid and potash, which are bought and used as fertilizer. A complete fertilizer is one that contains all three of these components — nitrogen, phosphoric acid and potash. Its composition is generally indicated by figures representing the available amounts of the three ingredients as shown by a chemical analysis, and is expressed in percentage.

The order is always (1) nitrogen; (2) phosphoric acid; (3) potash. For example, a 2-8-4 fertilizer is one containing 2 per cent nitrogen, 8 per cent phosphoric acid, 4 per cent potash.

The production of commercial fertilizers has become a large industry in this country. The annual sales in normal times amount to over \$100,000,000, most of this amount being spent for complete fertilizers. In many states the sale is regulated by law. A chemical analysis of each brand is required, and this guaranteed analysis must be made public. It must appear on each package of fertilizer for sale, usually on a tag attached to the package, and may be printed in a bulletin or circular for free distribution. In this way both

the farmer and the honest manufacturer are protected. Even with this safeguard, the farmer may be misled if he is unable to understand the meaning of the analysis when he reads it.

Meaning of a fertilizer analysis. — The record of a fertilizer analysis, as it appears on a package, may at first seem confusing, especially if a complete analysis is given. A simple rule, easily followed, is to consider only the *lowest* stated amounts of *available*, or *soluble*, ingredients. The following is an example of an analysis on a fertilizer tag with an application of the rule:

ANALYSIS

<i>Nitrogen</i>	1.64 to	2.46 per cent
Nitrogen as ammonia.....	2.00 "	3.00 " "
Soluble phosphoric acid.....	5.00 "	6.00 " "
Reverted phosphoric acid.....	3.00 "	4.00 " "
Insoluble phosphoric acid.....	1.00 "	2.00 " "
Total phosphoric acid.....	10.00 "	12.00 " "
Phosphate of lime.....	22.00 "	24.00 " "
<i>Available phosphoric acid</i>	8.00 "	10.00 " "
<i>Potash</i>	3.00 "	4.00 " "
Sulfate of potash.....	1.64 "	2.46 " "

Applying the rule, 1.64 per cent nitrogen, 8 per cent phosphoric acid, and 3 per cent potash are the only items to be considered. In each case the lowest amount is taken, for there is no guarantee that the higher percentage will be found, although it may be.

Ordinarily the analysis as indicated on a fertilizer tag is not presented in as much detail as the above example. The form of the certificate printed at the top of the following page illustrates a more common practice:

No. 10456
JOHN DOE & COMPANY,
of Lafayette, Ind.,

Guarantee this

Doe's Grain and Clover Producer
to contain not less than
1.6 per cent. of total nitrogen, (N).
2.0 per cent. of potash, (K₂O),
soluble in water,
8.0 per cent. of soluble and reverted
phosphoric acid, (P₂O₅), and
2.0 per cent. of insoluble phosphoric
acid, (P₂O₅).

Purdue
Experiment
Station,
LaFayette, Ind.

E. G. Groul

State Chemist.

How to estimate the value of a fertilizer.— It is the custom in most states for the state department having control of fertilizer inspection to make annually an estimate of the value, per pound, of nitrogen, phosphoric acid, and potash. These values may be obtained by writing to the State Agricultural Experiment Station. For example, in 1921, the estimate prepared in Indiana was 20 cents per pound for nitrogen, 7.5 cents for phosphoric acid, and 7.5 cents for potash. The figures obtained from state authorities may be used to determine the relative values of similar mixtures offered for sale by different manufacturers, or of different mixtures sold by one manufacturer. They may, in some cases, roughly indicate what a reasonable selling price should be.

Taking the analysis of the fertilizer given in the example, a ton (2000 lbs.) will contain:

Nitrogen.....	1.64 per cent (32.8 lbs. at 20 cts.)	\$6.56
Phosphoric acid.....	8.00 per cent (160 lbs. at 7.5 cts.)	12.00
Potash.....	3.00 per cent (60 lbs. at 7.5 cts.)	4.50
Total value.....		<u>\$23.06</u>

To this amount should be added enough to cover reasonable expenses and profit of the dealer.

If another similar brand should have a calculated value of \$22.00, and another of \$25.00, these three brands should sell at nearly the same price. A difference of five dollars in the price would be unreasonable, for all three are relatively the same in value.

Prices of fertilizers vary from year to year. Those quoted in the above example have not reached the pre-war level but they serve to illustrate the method of an approximate determination of the value of a fertilizer.

Home mixing of fertilizers. — Where large amounts of fertilizers are used, it is often more economical to buy the ingredients separately and mix them at home. A clean floor, a shovel, and a pair of scales with which to weigh the correct amount of each ingredient, are necessary.

After the ingredients have been weighed, the lumps should be pulverized and the material thoroughly mixed. The method of calculating the amounts is as follows:

All calculations are based upon the percentages of nitrogen, phosphoric acid, and potash in the materials purchased. The following are the percentages of the most common forms of fertilizing materials:

Nitrate of soda, 16 per cent nitrogen.

Sulfate of ammonia, 20 per cent nitrogen.

Dried blood, 10 per cent nitrogen.

Acid phosphate, 14 to 16 per cent phosphoric acid (the guaranteed analysis will give the exact percentage).

Muriate of potash, 50 per cent potash (the guaranteed analysis will give the percentage of potash in other forms of potash).

The amount of nitrogen in a ton (2000 pounds) of nitrate of soda is found by taking 16 per cent of 2000. ($2000 \times .16 = 320$.) A ton of nitrate of soda will therefore contain 320 pounds of nitrogen.

If a ton of a mixture containing 2 per cent of nitrogen is wanted, the quantity of nitrate of soda needed to furnish this amount of nitrogen (2 per cent) may be found as follows: A ton (2000 pounds) containing 2 per cent of nitrogen will have 2 per cent of 2000 ($2000 \times .02 = 40$), or

40 pounds of nitrogen. Since nitrate of soda contains 16 per cent nitrogen, one pound of nitrate of soda will contain .16 of a pound of nitrogen ($1 \times .16 = .16$). Therefore as many pounds of nitrate of soda will be required to furnish 40 pounds of nitrogen as .16 is contained in 40 ($40 \div .16 = 250$), or 250 pounds.

Similar calculations can be made of phosphoric acid and of potash by substituting 14 per cent for phosphoric acid and 50 per cent for potash.

Suppose a ton of a 4-8-3 fertilizer is to be made, how much nitrate of soda, acid phosphate, and muriate of potash will be needed? First, find the number of pounds of nitrogen, phosphoric acid, and potash in a ton of a 4-8-3 fertilizer:

$$2000 \times .04 = 80, \text{ or } 80 \text{ pounds of nitrogen.}$$

$$2000 \times .08 = 160, \text{ or } 160 \text{ pounds of phosphoric acid.}$$

$$2000 \times .03 = 60, \text{ or } 60 \text{ pounds of potash.}$$

Next, find the amounts of nitrate of soda, acid phosphate, and muriate of potash necessary to furnish the required number of pounds of nitrogen, phosphoric acid, and potash:

$$80 \div .16 = 500, \text{ or } 500 \text{ pounds of nitrate of soda needed to furnish } 80 \text{ pounds of nitrogen.}$$

$$160 \div .14 = 1142.8, \text{ or } 1142.8 \text{ pounds of acid phosphate needed to furnish } 160 \text{ pounds of phosphoric acid.}$$

$$60 \div .50 = 120, \text{ or } 120 \text{ pounds of muriate of potash needed to furnish } 60 \text{ pounds of potash.}$$

The cost of such a mixture may be easily found by multiplying the calculated amount of each ingredient by its average market price per pound, and finding the sum of the products.

When buying the ingredients for home mixing, better rates may be obtained by buying in car-load lots. The saving is not only on the original cost but also in the reduction of freight charges.

SOIL AMENDMENTS

What a soil amendment is. — Certain substances are often added to the soil for the purpose of improving it physically

by making its structure more favorable for crop production, and for the purpose of promoting chemical and bacterial action. The most valuable of these substances is lime, although land plaster, common salt, and others may be used occasionally.

How lime benefits the soil. — Some of the calcium which occurs in lime is needed by plants as plant food, but lime has other important uses also that make its presence in the soil desirable. Lime is used to bring about granulation in clay soil; to liberate or make available such plant-food materials as potash; to neutralize soil acids; and to aid useful soil bacteria in their work.

Acid soils. — Whether or not a soil is acid is of considerable importance, for most farm plants do not grow well upon acid soils. Legumes, such as alfalfa and red clover, are especially sensitive to soil acids. A soil is regarded as an acid soil (1) when acids are actually present in injurious amounts, or (2) when the soil is deficient in lime. In either case an application of lime is needed to restore favorable conditions for the growth of plants of greatest value in general farming.

How to know when lime is needed. — Even in limestone regions lime is often lacking in the soil, particularly on old farms. It is a safe practice to test the soil of each field in order to determine whether lime is present or not. There are several simple tests that may be applied. The following is suggested: Add several drops of a weak acid, such as dilute hydrochloric acid, to a handful of the soil; if small bubbles of gas appear the presence of lime is indicated; if no bubbles appear and there seems to be no action of the acid on the soil, the absence of lime is indicated.

How to lime the soil. — Experience has shown that finely ground limestone is the most economical and satisfactory

form in which to apply lime. Air-slacked lime may also be used when it can be obtained without too much expense. Unslacked lime is not only more expensive than ground limestone, but is likely to do more harm than good by destroying the organic matter with which it comes into contact. If limestone is applied, it should be at a rate of about two tons per acre the first year, omitted the second year, and one-half ton each year thereafter. Some farmers prefer to make a larger application each four or five years. If water-slacked lime is used, only three-fourths as much is needed. There is some difficulty in applying lime to the land, but this has been largely overcome by the use of lime spreaders especially designed for this work.

CHAPTER VI

SOIL MANAGEMENT

What soil management is. — We have seen that plants require water, in the form of capillary water with a reserve of free water below; oxygen; certain food materials; and a sufficiently loose arrangement of the soil particles to permit roots to push their way through easily. When soil is in good condition to furnish and continue to furnish these requirements for plant growth, it is said to be in good tilth. Soil in good tilth is somewhat difficult to describe. "It is porous but not too loose; firm but not hard or consolidated; close-grained but not run together nor adhesive." Securing and maintaining good tilth and sufficient amounts of food materials for plant growth is the object of soil management. Three aspects need to be considered somewhat in detail: the means employed in farm practice; the special problems presented by variation in soils; the relation of systems of farming to soil management.

HOW GOOD TILTH IS SECURED AND MAINTAINED

In general farm practice there are several means employed to secure proper soil conditions. Among the most important are drainage, tillage, rotation of crops, use of barnyard and green manure, and application of lime.

Drainage. — Drainage has been referred to by a soil expert as "the foundation of good soil management." This state-

ment may be better appreciated by summarizing the various effects of drainage. Some of these effects have already been considered; such as modifying the soil temperature, securing a larger feeding area for roots of plants and a better soil ventilation. To these may be added: modifying the structure of heavy soils so as to make them granular and porous; affording conditions favorable for action of bacteria in changing organic matter into available plant food; making it possible for larger amounts of natural plant food of the soil minerals to become soluble. On the whole, drainage may be considered as the first essential of a productive soil.

It will be seen from this list that drainage is the means of helping to secure a variety of conditions, each of which is important in plant production.

Tillage. — A well-drained soil, important as it is, will not produce satisfactorily unless it is well tilled. The soil must be properly worked and handled in order to secure the best results from good drainage. Each operation of tillage, such as plowing, disking, rolling, and cultivation, has a definite purpose in rendering the soil productive, and each must be done at the right time and in the right way to become the most effective. Plowing when the soil is just right as to moisture content increases the amount of granulation, a condition which has been referred to as good tilth. Disking and harrowing further increase granulation until the seed-bed is made ready to receive the seed. Rolling may prepare the ground in some instances for more effective use of the harrow, or after the seed is in the ground, it may make the soil in the seed-bed compact, thereby bringing moisture from below and thus hastening germination. Finally, cultivation forms a mulch which prevents the loss of water through evaporation.

It is through tillage that the greatest effort is expended in helping plants to secure their needs for growth and development. Much skill and intelligence are needed in order that the expenditure of time and energy may be most effective.

Rotation of crops. — By crop rotation is meant a system of planting in which there is a change of crops on the same soil from year to year. There are a number of advantages to be secured by a proper rotation of crops. Some have already been noticed, such as legumes in rotation for fixing the atmospheric nitrogen into compounds available for other crops. Others are to be considered in discussing cropping systems. But crop rotation has also some direct effects on the soil that deserve attention in soil management. Roots of plants affect soil structure, especially in clay soils, by making it more open and porous. Some plants, such as barley, millet, and wheat, are shallow-rooted; some, such as clover, alfalfa, and sugar beets, are deep-rooted; others, such as corn and oats, are neither very shallow nor very deep. A rotation of crops having different root depths would do more to improve soil structure than a rotation of crops having similar root systems.

The greatest effect of crop rotation on soil improvement is gained by alternating tilled crops, such as corn or cotton, with untilled crops, such as clovers and grasses. In this kind of rotation tillage will bring about a thorough mingling in the soil of the roots and crop residue of the previous, untilled crop.

Barnyard and green manure. — The value of organic matter in increasing the water-holding capacity of the soil and keeping up the nitrogen supply has already been emphasized. Organic matter derived from either barnyard or green manure

improves the structure of soils; those of coarse texture like sand, by filling up the large spaces; those of fine texture like clay, by separating the fine particles and also by inducing granulation.

Lime. — The various benefits of lime were summed up in the previous chapter in the discussion of soil amendments. Attention is called to it here, because it is especially useful in modifying soil structure and should therefore be considered in any discussion of soil management. In dealing with sandy soils a light application of lime tends to make them more compact; in clay soils a heavy application promotes granulation.

VARIATION IN SOILS

Soils differ greatly not only in different localities but in parts of the same locality. There are all variations from almost pure sand in very light soils to almost pure clay in very heavy soils.

The Bureau of Soils of the United States Department of Agriculture has made a very complete study and classification of the soils of the entire country; maps have also been prepared showing the distribution of various soils in several counties of each state. Several of the great agricultural states, like the state of Illinois, have supplemented the work of the Bureau by more extensive and detailed description of soils within the state. These two sources of information concerning the kinds of soils and their distribution are mentioned because of their value for reference in the study of soils in any particular locality. Other information to assist in such study may often be obtained from the State Agricultural Experiment Station, and sometimes from the State Department of Geology.

Space will not permit a description of the entire list of soils included in the classification made by the United States Bureau of Soils. It will be sufficient in this brief discussion of soil management to include only those already mentioned; sandy, sandy loam, clay, and clay loam.

Sandy soils. — We have seen that these soils are composed of coarse particles. Such soils are easily worked and are therefore valuable for special kinds of farming, such as truck farming, where much work with hand tools is required. They are also easily warmed, a property that is very desirable when a long growing season or an early crop is needed. This property is due to the fact that water readily drains from sandy soils, so that most of the heat received from the sun is used in increasing their warmth instead of in evaporating the water. Crops may often be started in sandy soils two weeks earlier than in heavier soils.

But sandy soils have two serious defects; a small water-holding capacity, and an insufficient store of plant-food materials. To correct these defects is the greatest problem in the management of sandy soils.

The water-holding capacity may be increased by the application of organic matter, such as manure. Such material is capable of holding a large amount of capillary water. Besides, when it fills the spaces between the larger particles of sand, the water-holding power of the sand itself is increased. To a certain extent, water may be controlled by handling the soil in such way as to keep the particles close together, especially by plowing and rolling. If a plow with a sloping moldboard is used in plowing sandy soils, the furrow slice will be turned without breaking much, thus tending to make the soil more or less compact. The use of the roller after leveling the ground with a harrow will also aid in compacting

the soil. These three methods when combined will greatly increase the water-holding capacity of sandy soils.

The loss of water from sandy soils through evaporation may be prevented by forming a good mulch. A mulch on these soils lasts much longer than on heavier soils. In fact, were it not for the necessity of cultivation for removal of weeds, the mulch which forms at the surface of sandy soils would often be sufficient to prevent loss of water, without much cultivation. The effectiveness of a natural sand mulch may be seen easily by examining a pile of sand. If some of the top, dry layer is scraped away, the sand below will be found moist.

The ease with which water drains from sandy soils and the naturally large spaces among the particles promote good aëration. Therefore, no special measures need be taken to keep up the supply of soil air. The difficulty, if any, will be in the other direction. Owing to the presence of so much oxygen, nitrification is apt to go on too rapidly, so that nitrates tend to be formed faster than they are needed, and consequently are drained off and lost. These losses may be reduced considerably by compacting the soil, as suggested for control of water.

Large applications of manure serve the further purpose of supplying food material which is so much lacking in sandy soils. But manure contains too great a proportion of nitrogen to that of phosphoric acid and potash to be used to advantage without correcting or balancing. According to the facts presented in a previous chapter, the application of phosphoric acid, in the form of both rock phosphate and acid phosphate, would seem to be desirable; the rock phosphate to furnish a store of phosphoric acid to be made slowly available, and acid phosphate for immediate use. Since sandy soils are

naturally deficient in potash, it is necessary to make up this deficiency. The form of potash used makes little difference. The one selected may depend upon the form most easily and cheaply obtained. In some instances wood ashes, containing about five per cent of potash, might prove to be more economical than the expensive muriate or sulfate of potash.

If manure is used its composition should be taken into account. The proportion of nitrogen, phosphoric acid, and potash in manure, expressed as a complete fertilizer, is about 10-5-10. This should be balanced by the addition of sufficient phosphoric acid and potash to make the proportion something like 3-8-2. The amount of each ingredient to be added in order to secure this proportion may be easily calculated by the use of simple arithmetic.

Clay soils. — We have seen that clay soils, because of their fine particles, have a great capacity for holding capillary water. Due to the same formation they also possess another valuable quality — solubility. For this reason they are regarded as rich soils. Material in a finely divided condition presents a larger surface for contact with water than a coarse material like sand. Consequently, such material is much more soluble. The effect of the size of particles on solubility is shown by comparing the rate at which powdered sugar is dissolved with that of sugar in lumps. Sugar in the former condition dissolves much more rapidly than in the latter. Even glass, which under ordinary conditions is regarded as insoluble, if made into very fine powder, will dissolve to some extent in water.

To offset these two valuable attributes of clay, there are several disadvantages which must be overcome as far as possible. Clay is hard to handle. It is sticky when wet and hard when dry. There is a very short period during which

clay is neither too wet nor too dry to work to advantage. If handled when too wet it puddles or runs together; if too dry, it forms clods. In either case the harmful effects may extend over a period of several years. It is therefore a serious matter to decide just when to plow or work such soils. A good deal of experience is necessary in order to recognize the right time. Even then it is not always possible to do the work at the time when it is most needed. The successful handling of clay soils depends upon using the period in which they can be safely worked.

How clay may be made easier to work. — The fact that clay becomes sticky when wet and hard when dry is due largely to its very fine particles. If these particles can in some way be brought together into small groups or granules, the clay will lose to some extent, these objectionable features and may be much more easily handled. Furthermore, when it is in a granular condition, it is easier for roots to penetrate it, and it will also retain most of its water-holding power.

A granular condition of clay may be brought about by the addition of lime or finely-ground limestone. In some way lime causes the fine particles of clay to mass together into small granules. The effect of lime on clay may be illustrated by making one ball of wet clay and another of clay mixed with a small quantity of lime. When both balls are dry, it will be found that the one mixed with lime will break more easily than the one made of pure clay.

Another method of improving clay soils and making them easier to handle is by applying coarse organic matter, such as straw or coarse manure, or by growing plants having large root systems. When either material is thoroughly mixed with the soil by plowing and disking, it tends to separate the fine particles and produce granulation.

To a certain extent also, thorough tillage, practiced through several seasons, and good drainage will secure a better condition of heavy soils, by bringing about granulation. Alternate freezing and thawing, and wetting and drying, are natural means tending to produce the same results.

It would be good farm practice to employ all four methods, especially since lime, organic matter, tillage, and drainage have other important uses besides that of improving clay.

It happens that putting clay soils in the best condition for handling puts them also in the best condition for plant growth. Granulation increases aëration, allows roots of plants to push their way more readily through the soil, and promotes better drainage from the top layers, thus removing the water so that the soil is more easily warmed in the spring.

Although clay soils are naturally rich in plant-food material, the supply is by no means inexhaustible. The material taken out of the soil by crops must be replaced from time to time, if permanent fertility is to be maintained. This applies especially to organic matter, the removal of which not only lowers the nitrogen content, but also affects the structure by reducing granulation. Although the supply of phosphoric acid is greater than in sandy soils it must be replenished, for which purpose the rock-phosphate-manure method is probably the most economical. In a few regions such as the limestone valleys and uplands of central Kentucky and Tennessee, the natural supply of phosphoric acid seems to be adequate. Potash is generally abundant, but it may be applied to advantage as a light dressing at the time of planting or sowing, since the growth of young plants is greatly stimulated by potash.

Loam soils. — Loam soils, being a mixture of sand with clay and silt, have some of the properties of each. To a

certain extent, the presence of the one overcomes the defects of the other. Thus, the sand in loam makes the soil more easily worked and produces better aëration, while the presence of clay and silt increases the amount of plant food and the capacity for holding capillary water. Loam soils are considered very valuable because they require less effort to keep them in a condition of good tilth. When a loam is very sandy, the same measures should be taken to improve it as are necessary for improving sandy soils. When it is a clay loam, it needs treatment similar to that needed by clay soils. But in either case the soil may be put into a condition of good tilth much more easily than sand or clay.

The same attention must be paid to keeping loam soils permanently fertile that has been indicated in the discussion of sandy and clay soils. These soils, because naturally rich and productive with a minimum of labor, are likely to be neglected until loss of fertility is noticeable. When this point is reached, it requires much more trouble and expense to restore the fertility than would have been necessary to maintain a constant or increasing fertility. Besides, in the latter method there is the additional gain in securing the advantage of a uniformly high production of crops.

SYSTEMS OF FARMING AND SOIL MANAGEMENT

It is clear from what has been said that keeping up the soil fertility is of primary importance in any system of farming. The general principles to be applied are the same, whatever the system. The differences lie in the kinds of natural soil, in climate, in crops, and in animals. For example, one farm having sandy soil must be handled in much the same way as any other farm having the same kind of soil.

But the kind of crops and animals produced may be entirely different. The problem on any farm is to make the best of the soil that it has; restoring its fertility if need be, but always keeping it up to a high standard of production. However modified by the kind of farming undertaken or by the influence of climate and other conditions, this is an essential basis for success. Here is where the farmer is able to make his contribution to the conservation of our natural resources.

The real test of good soil management is in the maximum production of crops and the maintenance of soil fertility at the same time. In general, the soil should be so managed as to produce the highest yield possible of the crops best suited to that particular soil. Since soils differ greatly in natural fertility, it is too much to expect equal production from all soils, but not too much to expect that each approach its possibilities.

Having considered at some length the application of the principles of soil management, we are now ready to take up the question of what use to make of the soil. By this is meant a choice of crops that will secure the best returns from the soil.

CHAPTER VII

CROP PRODUCTION

THE previous chapter was devoted to a summary of some of the most important principles relating to the management of soils. These principles should be applied, as far as possible, to the production of all crops, because much of the time and labor devoted to production is spent in handling the soil. If the soil is not well handled, the crops are not likely to produce enough to pay for the time and labor spent upon them.

Crop production, as a farm enterprise, involves two things: First, the selection of crops that are best adapted to a particular farm; second, a choice having been made, the handling of each crop so as to bring in profitable returns. Although it is necessary for successful production to know many facts about each crop, there are several important points relating to selection and handling that are more or less common to all crops. These should be understood before taking up a particular crop.

SELECTION

There are at least three things that should receive consideration in making an intelligent selection of crops: First, the crops should be adapted to climatic conditions; second, they should be adapted to the soil on which they are to be grown; third, they should fit into a plan of management known as a cropping system. In order to understand the

relation of each of these factors to crop production, it will be necessary to consider each separately and somewhat in detail.

How climate affects the choice of crops. — In relation to crops climate plays an important part. It affects them chiefly through rainfall and temperature, for these determine the length of the growing season — the period from seed-time to harvest. In a temperate climate like that of the Corn Belt, this period continues from about the middle of May until frost appears in the fall. It follows that the growing season is longer in the South than in the North. Since rainfall is abundant in the Corn Belt, temperature becomes the main factor. But in other parts of the country where the temperature is relatively high during the entire year, as in New Mexico, Arizona, and Southern California, rainfall becomes the chief factor. In these regions the so-called rainy seasons determine the growing season of the crop. By timing the planting so as to take full advantage of the rainfall, it is possible to produce barley, corn, wheat, beans, and many other crops. In many places where the annual rainfall is low, as in the Western States, crops are made independent of rain by the application of water through irrigation.

Adaptation of crops to climate. — By adaptation is meant the use of only such crops as are suitable to climatic conditions; that is, whose growing periods correspond to the season of temperature and moisture favorable to the best plant growth. For example, cotton has too long a growing season to be used successfully as a northern crop. The question of selecting crops suited to climate has been pretty well settled by experience, especially in the great farming sections of the Middle West. A study of crop production in any well-established farming region will usually indicate the kinds of agricultural plants best suited to that region.

How soil affects the choice of crops. — Crops must also be suited to the soil of a particular region. This is next in importance to their selection according to climate. A region may have the right climate for a certain crop, but the soil in many places may not be adapted to this crop, or the reverse may be true. For example, rainfall and temperature may be favorable for potato-growing, but if the soil is too heavy, the results will not be satisfactory. It follows, then, that in choosing crops to be produced on a farm, two things must be considered: one, the soil requirements of each crop; the other, the nature of the soil on the farm. The soil requirements of our staple crops will be considered later when each crop is discussed.

The chief characteristics of the four great soil classes (sandy, clay, sandy loam, and clay loam) have already been sufficiently described. Attention has also been called to the work of the U. S. Bureau of Soils and of the State Agricultural Experiment Stations, as sources of further information in regard to soil distribution. Soil maps of a number of counties in each state have been prepared. When available, these maps are valuable for the study of the agricultural possibilities of these regions. Such a map may locate for the farmer the different kinds of soil on his farm, thus aiding him in making a selection of crops and in managing the soil to secure larger production.

The application of these facts to crop selection is: First, to learn in general the kind of soil best suited to each crop; second, to make sure that the particular soil which is to be used meets the needs of the crop desired. It may be when these two things are considered that the crop intended will not fit into the soil conditions. In such cases more favorable crops must be selected. It often happens that a change

may be made which will answer the purposes of the crops originally intended, and, at the same time, secure a much larger production. For example, alfalfa may be desired, but when soil conditions are examined, they may be found to be unsuited to this crop. But these conditions may not be so unfavorable for the production of red clover. Since red clover has nearly the same uses and value as alfalfa, it may be substituted with the probability of a much greater production. Many disappointments in attempting to grow alfalfa and other crops are doubtless due largely to a failure to consider the soil needs of the crop in relation to the actual soil conditions on the farm.

How planning a cropping system affects choice of crops. — By "cropping system" is meant the operation, through a period of several years, of a definite plan of crop production for the entire farm. A number of things are involved in making such a plan. The most important are the maintenance of soil fertility; control of injuries and losses due to weeds, insects, and plant diseases; the disposal of crops (whether as feed for stock raised on the farm or as cash crops); the competition with crops of better favored regions; and distribution of labor.

How to manage crops so as to maintain soil fertility. — Experience has shown that when one crop is grown continuously on the same field, there is a decrease in yield, often to a point where there is no profit. There are several reasons for this. The continual removal of organic matter destroys good tilth, especially by reducing granulation and the water-holding capacity of the soil; the removal of plant-food materials tends to exhaust the supply, particularly of nitrogen and phosphorus; certain poisonous substances, called soil toxins, accumulate and interfere with plant growth; the

difficulty of controlling plant diseases, weeds, and injurious insects is increased. A liberal application of organic matter may reduce the evils of continuous cropping in a measure, but not enough to justify following such a system. An experiment with a 12-year continuous crop of corn, where clover and rye were used as green manure and where fertilizers were applied, showed but slight profit compared with the yield on the same kind of soil, where rotation of crops was employed.

It has been found that where wheat is grown continuously, the loss of humus from the soil amounts to 1800 pounds an acre, but on the same kind of soil where rotation is practiced, there is a gain of from 1500 to 2000 pounds. The various advantages of crop rotation may be summed up as follows: It increases the amount of humus in the soil, thereby providing for greater water-holding capacity and better general condition for plant growth; it corrects the injurious effects of soil toxins or poisons; it makes possible an easier control of plant diseases, weeds and injurious insects.

The two chief means of keeping up the fertility of soil are first, the use of barnyard and stable manure; second, the rotation of crops. The latter is of especial importance in making a choice of crops and needs to be considered from this point of view, somewhat in detail. There are two essential features of a good crop rotation. One is to include some legume in the rotation; the other, to include some cultivated crop so as to control weeds. The following general rule for rotation of crops has been suggested: cultivated crops prepare conditions favorable for grains; grains prepare for legumes like clover, and grasses; and legumes and grasses, in turn, prepare the land for cultivated crops.

The kind of legume to be used depends upon soil and

climate. In case legumes do not grow readily, the soil should be put into a condition favorable for their growth. Usually the addition of lime will be sufficient but in some instances better drainage may also be required. The choice of other crops in the rotation, aside from consideration of soil and climate, depends upon the kind desired. That is, any kind of a crop may be used provided it will yield profitably under the system of farming in operation. In the example given, where wheat, clover, and corn form the rotation, corn is the chief crop and the other crops serve to aid in its production. The wheat is generally used to secure a stand of clover rather than for the profit in itself and is expected to pay the expense of putting in the clover.

After the kind of rotation has been determined, the farm should be divided into as many equal parts or fields as there are kinds of crops in the rotation. In the example above, there would be three or a multiple of three. The shape and arrangement of the fields depend upon the lay of the land and upon the previous arrangement. In order to facilitate plowing and cultivating, and the division of fields for feeding purposes, as in "hogging corn," long, rather narrow fields are to be preferred. In many cases an entirely new arrangement of the fields may be worth while, not only to make better provision for a system of crop rotation, but also to save fencing and labor.

How to manage crops so as to control losses due to weeds, insects, and plant diseases. — The losses due to these agencies are very great. No means has been found that will entirely prevent such losses but they may, to a certain extent, be controlled by proper crop rotation. The application of this method of control and of other means is considered in detail in later chapters.

How disposal of crops may affect the choice in a cropping system. — Farming is a business. Crops are produced for profit. Obtaining a profit depends not only upon the quantity and quality of the crops raised, but also upon the availability of markets. For example, an abundant yield of onions of the finest quality might be produced on a farm so remote from markets as to make it impossible to dispose of them with profit. Access to market and trade demands must be considered in selecting crops. Usually, in long-settled communities experience has solved this problem, so that it may be advisable to follow the practice of the best farmers of the community. In new farming regions, the selection of crops which are adapted to climatic and to soil conditions and which may be disposed of profitably is a matter not always easy to decide. Much farm land is sold on a promise of abundant crops, with no mention made of marketing conditions.

Cash crops. — Crop farming, although extensively practiced, is not only less profitable than stock farming, but results sooner or later in a loss of soil fertility. Crops are taken from the farm and sold. Consequently, there is a continual drain of plant-food material in excess of that returned to the soil. Humus is also destroyed. This results in the reduction of the water-holding capacity of the soil, makes the soil harder to keep in good tilth, and tends to prevent much of the plant food from becoming available.

The removal and sale of a crop, however, may be justified in general farming, where farm animals furnish fertilizer, and a good rotation is practiced to keep up the soil fertility. The farm system which includes producing and selling a crop for cash has one advantage — it helps supply cash for running expenses. Potatoes, fruit, melons, tobacco, sugar beets, and vegetables are examples of cash crops.

Crops for feeding animals. — Emphasis has been placed upon the use of a cropping system that will secure the up-building of the soil. While keeping up the fertility of the soil is of primary importance, it must be managed so as to make farming a profitable undertaking. The use of crops to feed animals has already been referred to as a means of securing soil fertility. This use of crops is, at the same time, one that is profitable from a business standpoint. A study made of the profits on some farms in certain counties of Indiana, Illinois, and Iowa shows a much greater labor income from live-stock farming than that secured from crop farming. Of the 273 farms included in this study (made in 1914), 194 were stock farms with an average labor income of \$755; and 79 were crop farms with an average labor income of \$28.

If the purpose is to provide crops for feeding, we have another factor to consider in determining the kinds of crops to produce. Here the problem is to develop a cropping system that will provide crops adapted to climate and soil, include legumes in rotations and, at the same time, secure the right kind of feed for farm animals. This is by no means an easy problem. In the Corn Belt, the chief crop for feeding purposes is corn, which is supplemented by clover or some other legume. Much of the plant food removed by the crops is returned to the soil in the form of manure. For this region, experience seems to indicate that the system is a good one both from the standpoint of permanent soil fertility and of profitable farming. In other sections of the country, like western Kansas and Oklahoma, where the rainfall is too light for corn, millets and sorghums form the chief feeding crops. In the cotton states sudan grass and some kind of grain adapted to that region are used. These examples serve

to illustrate how the problem may be solved in different sections of the country under varying conditions of soil and climate. In each section there are several kinds of crops which are adapted to the particular climatic and soil conditions, and which are valuable also for feeding animals.

How competing crops of other regions affect the choice of crops. — Crops of one region are often grown in competition with crops of other regions. All seek the same market. When the cost of production makes it unprofitable to compete with crops produced elsewhere at less expense, another choice should be made. Usually a change has been forced by experience, and the custom of the community may be followed safely. For example, farmers of the New England States and of New York cannot profitably compete with farmers of the Corn Belt in producing corn. Consequently, the New England and New York farmers have found it more profitable to produce hay rather than corn.

How labor may affect the choice of crops. — Labor is another factor which must be considered in arranging a system of farming. It is important to distribute the work of crop production and other farm work throughout the year. Especially is it necessary to plan crops in such way that work needed on one crop will not interfere with that needed on another crop, and also that as little outside help as possible will be required. The matter of securing farm labor is a serious one, so serious that it must be considered carefully in any farm planning. If farm labor must be employed, experience seems to show that a farm system which will provide work for hired help during the entire year is the best plan. Since the labor in crop production is limited largely to the growing season and harvest, such a plan is difficult to operate successfully unless farm animals are kept.

Selection of crops. — Throughout this chapter the importance of selecting crops for the most profitable production has been emphasized. We have seen that such a selection involves several things: kind of soil to be used; soil and climatic conditions needed by the crop; place in a cropping system in order to maintain soil fertility and to control losses due to weeds, plant diseases, and insects; the use of the crop, whether as a cash crop or for feeding purposes; competition with similar crops in other regions; and distribution of labor.

The problem is to make a selection of farm crops to meet these requirements as far as possible. But in order to do this we need to know the most important things about each of a number of our common crops.

The next chapters will present in detail some of the facts we should know about various crops, such as corn, small grains, and forage crops that are especially useful in general farming; miscellaneous crops, such as cotton, potatoes, and tobacco that are usually regarded as cash crops; and vegetables and fruits which are important in some places as cash crops, and which should have a place on most farms for home use.

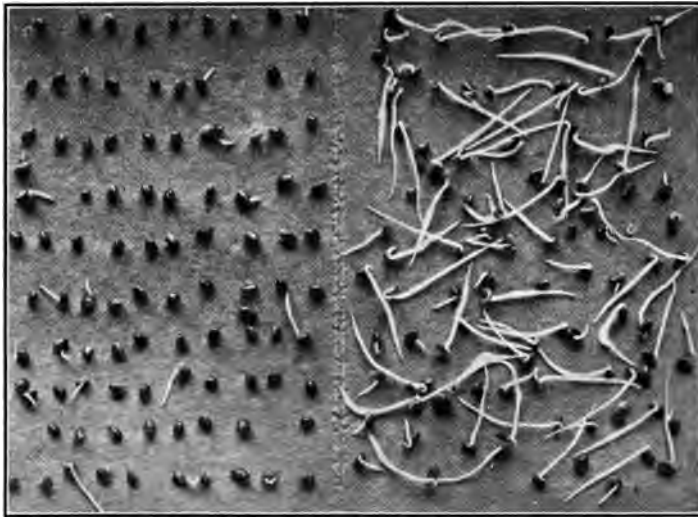
HANDLING CROPS

Having considered some of the most important points that have a general application in the selection of crops, we need next to inquire into the various farm operations necessary for crop production. This will include selection of seed, preparation of the seed bed, planting, cultivation, protection, and harvesting.

Seed selection. — There are at least four questions in seed selection that should be satisfactorily answered. Is it

the right kind or variety? Will it grow? Is it clean? Is it free from infection?

There are usually many kinds and varieties of plants included in any farm crop. There are, for example, as many as 1000 varieties of wheat. Bread wheats are subdivided, according to hardness and color, into soft white, soft red,

**A****B**

Results of a germination test of crimson clover seed.

A. Poor seed. B. Good seed. (U.S. Dept. of Agriculture.)

medium red, hard winter, and hard spring. Each of these subdivisions is composed of many varieties. For instance, the medium red wheats include such varieties as Fultz, Lancaster Red, and others. The point to be kept in mind is that many kinds and varieties of most farm plants are available, thus making it possible to select the one best suited to the conditions of production on a particular farm.

A Minnesota farmer would probably decide to raise flint corn rather than dent corn, because the former matures more quickly. But he would have to make a choice among several varieties of flint corn. He might choose Smut Nose because his neighbors had found that it yields well, or the Golden Nugget for some other reason.

If plants are to be produced, the seed must be capable of germination. There is no way of knowing this except by testing. For small seeds it is sufficient to choose one hundred seeds at random and place them between two pieces of damp cloth or paper, keeping them moist and warm until they have had time to sprout. The number which germinates determines the percentage of good seed. The rate of seeding or planting may then be based upon this percentage. If the seed tests fifty per cent pure, the rate of planting should be doubled. A different method generally used for testing seed corn is described in Chapter VIII.

Seed should be free from dirt and weed seed; from dirt, because of its effect on the rate of seeding, and from weed seed, because weeds interfere with the growing crop. It is not always possible to get perfectly clean seed, especially among small-seeded plants, such as grasses, but every precaution should be taken to reduce the impurities. The value of farm seeds free from weeds is discussed in greater detail in a chapter on weeds.

Finally, seed should not be infected with disease-producing germs. Seed will be pure in this respect if produced by perfectly healthy plants. But this assurance is not always possible. In cases of infection by oat smut or potato scab, a special treatment of the seed will destroy the infection. Details of the cause and control of plant diseases will be found in Chapter XV.

Preparation of the seed bed. — In the previous chapter, it was stated that the greatest effort in helping plants to secure their needs for growth and development is expended on tillage. Most of the tillage operations have to do with preparing the soil for seed. In other words, tillage operations prepare for the growth and development of plants. They begin with plowing and end with some operation that will leave the surface level, with the upper layer of the soil finely divided but granular in clay and loam soils, and somewhat compact in sandy soils. Such conditions of the soil are favorable for the germination of the seed and the development of the young seedlings.

In this connection, it is well to keep in mind soil and its relation to plants as discussed in detail in the previous chapters. The preparation of the seed bed means putting into practice some of the principles of soil management.

The thoroughness necessary for preparation of the seed bed varies considerably with different crops. Some crops, such as potatoes, require a deep open seed bed; others, such as wheat, need to have the sub-surface well packed. Modifications of the general procedure, required in preparing the seed bed for particular crops, will be pointed out when such crops are discussed.

Planting. — This refers to getting the plant started. In most cases it is done by sowing seeds, as with corn, wheat or oats; in others, instead of seeds, cuttings are used, as with potatoes or sugar cane; again, plants are started from seeds in a specially prepared seed bed and then transplanted, as with tomatoes.

The requirements for planting vary so much among farm plants that no general procedure can be outlined. Three questions arise with reference to the planting of any crop:

first, when to plant; second, how deep to plant; third, how far apart to plant.

The answer to the first varies with the length of the growing season and climatic conditions. The second depends largely upon the size of the seed. It is important to get the seed into the soil in the best position to give the plant a good start. It may be sufficient to scatter the seeds over the surface of the ground, as with some of the grasses; or it may require a uniform depth, as with corn. The third depends upon the size of the mature plant, and must take into account the room necessary for its best development. Sometimes, as with beets, the seeds are planted thickly; afterward the young plants are thinned, leaving only the strongest and most vigorous. If the crop is a cultivated one, sufficient distance must be allowed between rows for easy cultivation. Information concerning these three points and other points about crops, especially garden crops, is often condensed into a tabular form known as a planting table.

The questions of depth and distance are often best answered by the use of a machine for planting, one especially designed for planting the seed of a particular crop or easily adjusted to it. Machines are now available for planting all of our common crops. They not only do planting better than by hand but save much time and labor.

Cultivation. — Crops, known as cultivated crops, such as corn, potatoes, and cotton, must be intertilled from time to time in order to destroy weeds and to conserve moisture. Cultivation may also help in making plant food available and in enabling the soil to retain water from rainfall.

The principles of water conservation by means of a mulch have already been presented. The effect of weeds on growing crops is too well known to need further comment here. How-

ever, reference to accurate studies of these effects will be found in Chapter XVI.

Methods of cultivation, or intertillage, are essentially the same for all crops. They consist in stirring the soil surface by means of some farm implement. The most effective implement is a one- or two-row cultivator supplied with a number of small shovels.

The amount of cultivation depends somewhat upon the nature of the crop. In general, cultivation should be repeated often enough to keep down the weeds and to preserve a good mulch until the ground is well shaded by the growing crop. For example, four cultivations seem to be enough for corn. The yield is rarely improved by more than four.

Depth of cultivation has already been referred to; the conclusion being made that shallow rather than deep cultivation was to be preferred. There are at least four advantages in shallow cultivation: it gives the most effective depth for a mulch; it does not destroy the roots of the growing plants; it leaves the surface nearly level; it requires less energy to pull the cultivator.

Protection. — The growth of crops is interfered with by weeds, plant diseases, and insects. The effect and control of weeds will be referred to in a subsequent chapter on weeds. One of the problems of successful crop growing has to do with the control of plant diseases and insects. Each crop has its own difficulties with these destructive agencies. For example, wheat rust is a disease which attacks wheat, and sometimes timothy and other grasses; the Hessian fly confines its injuries chiefly to wheat. Some of the most important general facts relating to the control of plant diseases and insects will be found in Chapters XV, XVII. In the discussion of each particular crop, reference will also be made

to protection against its most harmful diseases and insect enemies.

Harvesting. — The chief questions arising with reference to harvesting a crop are when to harvest, and how to harvest?

The time to harvest is determined by the use to be made of the crop. For example, corn should be harvested when fully mature if the grain or fodder is desired, but at an earlier stage when the kernels are well-glazed, if silage is to be made. Some crops, such as clover and alfalfa, are in the best condition for harvesting during a very short period. Others, such as cotton, and corn if husked, have a rather long period. The length of the harvesting periods of different farm crops is of considerable importance when planning a cropping system which will give a proper distribution of labor.

The method of harvesting depends, of course, upon the kind of crop. But it should be one that gives the highest net return. With small production, as on a few acres, the profit may be greatest if done by hand, but on a large acreage machinery should be used.

The harvesting of corn furnishes an example of the relation of cost to method. If husked in the field, much of the fodder will be lost for feeding purposes. Since, as a rough feed, corn stover may be substituted for hay, whether or not to harvest the stover will depend upon the cost as compared with the value of the hay saved in feeding. If hay is high in price, harvesting the stover would probably be a good practice; otherwise, it would not.

Climatic conditions may influence the method of harvesting, as is the case with wheat. On the Pacific Coast, where summers are dry, wheat is generally harvested by means of a header; while in the humid regions of the east, it is cut and bound into bundles which are placed upright in shocks.

An important factor influencing both time and method of harvesting many crops relates to their preservation. When the moisture content in the harvested crop is high, it is liable to be injured by the action of molds and bacteria. Such crops as grains lose moisture as they mature. Delay in harvesting these crops until they are well matured favors their preservation. In 1917, an enormous loss of corn occurred, owing to its immaturity when husked. On the other hand, hay crops are cut before the plants are mature and, therefore, contain much water. Curing hay is essentially a drying process in which the water content is reduced below the danger point, that is, below the amount needed for the active growth of molds and bacteria.

To avoid this danger also, it is important to protect recently cut crops from rain as much as possible, as, for example, by putting wheat in shocks and hay in cocks.

Most of the farm practice in harvesting is the result of long experience and is, in general, a safe guide. It is well, however, to try to understand the reasons for the procedure that is followed in harvesting each crop.

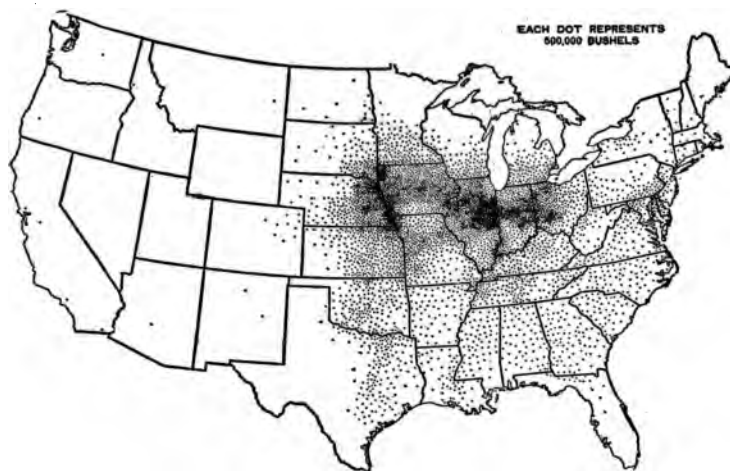
CHAPTER VIII

PRODUCTION OF CORN

Value of corn as a farm crop. — Corn is the great American farm crop. It is produced in nearly every state in the Union, the total yield for 1917 being 3,124,000,000 bushels, with an estimated value of \$3,500,000,000. It furnished the chief feed for 62,747,000 hogs, and helped support 43,291,000 beef cattle, 23,906,000 dairy cattle, and a large number of sheep and horses. The relation of corn to live-stock production may be seen by comparing the two in any large corn-producing state. For example, in Iowa, in 1915, the production of corn was valued at \$154,530,000, with a corresponding value of \$282,015,000 for live stock. A similar relation holds good for the entire country. Furthermore, when the corn crop is short, an increase in the price of live stock follows.

In spite of the immense total production of corn for the entire country, the average yield per acre is low. In no ten-year period has the average exceeded 28 bushels. Yet boys and girls who are members of corn clubs have produced more than 100 bushels on a single acre, in many states. In view of the success of these club members, it seems reasonable to expect that some of the principles of corn production learned in school will soon be put into practice, and in that way lead to a high production of corn in every community where corn is a common crop.

Kinds of corn. — For the general corn crop, except in the most northern parts of states lying on the Canadian border, dent corn is almost universally used because of its high yield. There are several varieties of dent corn, each having been developed to meet the conditions of a particular region. For example, the region of dent-corn production has been extended northward, by the development of varieties capable

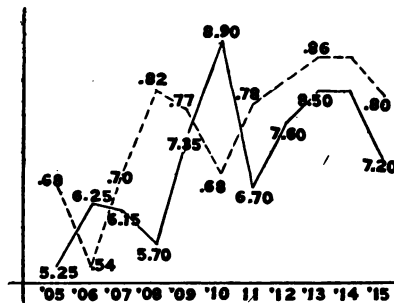


Distribution map of corn. Note position of the Corn Belt, perhaps the most favorable area in the world for corn. (U.S. Dept. of Agriculture.)

of maturing during the short growing period of those regions. In other places, as in the southern part of the Corn Belt, varieties have been developed to take the greatest advantage of a rather long growing season, thereby adding to the yield per acre. Some well-known varieties of dent corn are the Johnson County White, Boone County White, Reid's Yellow Dent, Leaming, Wisconsin number 7, and Silver King.

Only those varieties should be grown which experience

has shown are suited to a locality. Where there is any doubt as to the variety to use, the State Agricultural Experiment Station should be consulted. Corn growers' associations, such as the Wisconsin Associations, are doing much, by making careful tests, to find varieties adapted to special regions. In the Far North, as Northern New England, Northern New York, Michigan, Wisconsin, Minnesota, and North Dakota, flint corn is generally used instead of dent corn. Flint corn does not yield so well as dent corn, but it



Graph showing fluctuations in prices of corn and hogs over a series of years. Note that a variation in the price of corn is followed later by a similar variation in price of hogs until 1914. Here this relation is disturbed, probably due to the beginning of the Great War.

is able to mature in those northern sections because of its short growing season.

Sweet corn and pop corn are used only as special crops, not in general farming except for home use and for cash crops. There are several varieties of each, affording considerable range in choice to meet special needs and climatic conditions.

There are two other kinds of corn, but they are of little importance compared with the ones already mentioned; pod corn, distinguished by a husk around each grain, and soft corn, which, as its name indicates, is free from the hard covering of the kernels.

Climate. — That corn is extensively raised in all the states east of the Rocky Mountains, is shown by the map giving the distribution of corn production in the United States. In the extreme northern parts of the states on the Canadian

border the growing season is too short for the highest-yielding kinds of corn to mature; while in the western states, including those of the Rocky Mountains, the rainfall is too light to produce a good crop without irrigation.

The most favorable section for corn is the broad strip, known as the Corn Belt, extending from eastern Nebraska through Iowa, Illinois and Indiana to eastern Ohio. We have here the climatic influences most favorable for the greatest production of corn; a growing period of about five months, a high temperature, especially during the second half of this period, and an abundance of rainfall.

Soil. — Any well-drained soil containing considerable organic matter will produce corn profitably provided that climatic conditions are favorable, and that proper preparation of the soil and cultivation of the crop are secured. Sod-land, which has been in grass or clover for one or two years, is regarded as the best for corn.

Place of corn in a cropping system. — For two reasons corn should follow a legume in a rotation. First, the legume supplies nitrogen for the use of the corn plant and organic matter for increasing the water-holding capacity of the soil; second, the deep roots of the legume loosen the soil below the plow line, affording better drainage and better conditions for the growth of the corn roots.

Preparation of the seed bed. — When the land is plowed in the spring, it should be harrowed immediately; and if the soil is heavy, it should be disked. Harrowing is important to prevent the formation of clods and consequent loss of water. If it is well done, a good mulch is formed and, at the same time, a good seed bed is prepared. Thorough preparation of the seed bed puts the soil in the best possible condition to grow plants. In some instances, because of the

nature of the soil, the labor required will be greater than in others, but it is important that harrowing and disking be continued until the soil is well prepared.

Fertilizing. — The best fertilizer for corn is stable manure applied early enough to become well rotted before the crop is put in. The practice of spreading the manure in the winter while the ground is frozen is a good one for the Northern States. The manure adds nitrogen to the soil and promotes good conditions in the way already described. Manure should be balanced by the addition of phosphate of some kind and a small amount of potash. Most soils have in store a considerable amount of potash. In such cases only enough need be added to supply the plants during their early growing period, the time when they need it most, for the soil furnishes the rest.

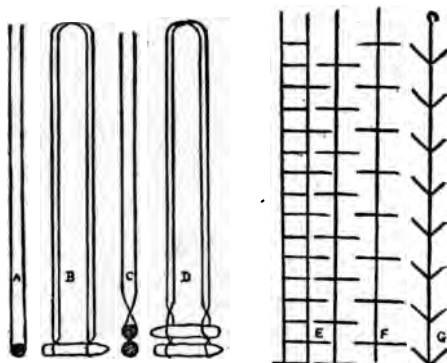
There are several ways of applying a fertilizer that are in common practice. The method already considered, that of spreading a mixture of rock phosphate or acid phosphate and manure, will provide most of the phosphoric acid needed. A light dressing of acid phosphate and potash spread over the ground and worked in with a harrow, will complete the ordinary fertilizer requirements for corn. In this way there will be plenty of available nitrogen, phosphorus, and potassium for the young plants, and an abundant supply in store to be drawn upon later, as it is needed. Some farmers fertilize heavily for a crop, such as wheat, in a rotation with corn. The residue from this application remains to be used later by the corn.

Seed selection. — The use of good seed corn is quite essential for production, but is a matter much neglected. Too often, just before planting time, a selection is hastily made from the crib, with a poor stand and inferior crop as a

result. It takes just as much work to get the land ready, to plant, and to cultivate a poor crop as it does a good one. Therefore, there is a clear gain in using seed corn of a high-producing strain, having perfect germination when tested. It is not uncommon to find on neighboring farms fields of the same kind of soil, which have had equal care in preparation of the land and cultivation of the crop, showing a marked difference in

yield in favor of the one where careful attention was given to the selection and testing of the seed. The only sure means of knowing whether seed corn will make a good stand is to make a test for germination. The value of making such tests on a large scale was emphasized in the spring of 1918. Because corn of the previous season had failed to mature, there was an almost universal shortage of seed corn throughout the Corn Belt. Extravagant prices were paid for corn that would germinate although it was inferior in other particulars. Those farmers who planted corn selected from the crib as usual failed entirely to get a stand. While other farmers, who planted only seed showing a high percentage of germination in the test, had no trouble whatever.

Corn intended for seed should be carefully inspected, ear



Two methods of holding ears of corn to dry for seed.

A, B, C, D.—steps in making a sling for corn ears from binder twine.

E, F, G.—steps in making a seed corn rack from a piece of woven-wire fencing material.

by ear. Those ears lacking in good shape, size, or in shape of kernels, or that seem to be light in weight should be thrown out. A germination test should then be made of the remainder. Such a test is so familiar that only the main points need be given.

The essential features of the germinator are a device for identifying the groups of kernels with the ear from which they are taken and some provision for moisture and warmth.

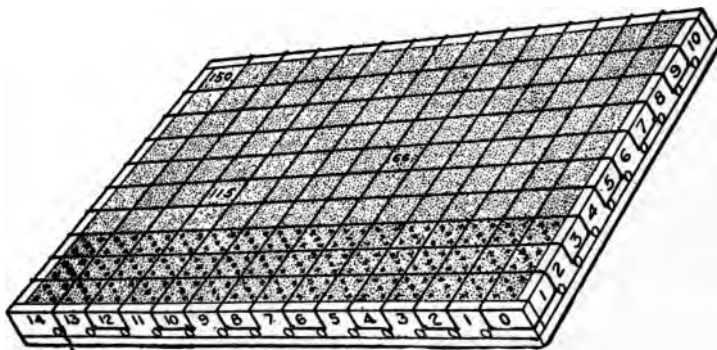


Diagram of a simple seed tester for corn germination. Described in text.
(U.S. Dept. of Agriculture.)

The ears should be numbered, or so arranged, that each ear may be identified readily after the test has been made. At least five kernels should be removed from different parts of the ear and placed in a square of the germinator numbered to correspond to the number or position of the ear selected. When all the ears have been disposed of in this manner, the tester should be covered and put in a warm place. After five or six days, when inspection shows that germination has taken place, each group of kernels should be examined. If a group is found where one or more kernels has not germi-

nated, the corresponding ear should be set aside. Only those ears which the test has shown to have perfect germination should be saved for seed.

The time and labor spent in preparation to secure a good stand of corn is insignificant compared with the gain in yield. A crop that must be replanted rarely matures. By comparing the number of stalks per acre in a perfect stand with the number in a poor stand some idea of the difference in value may be obtained. In a good stand, there might be 10,000 to 12,000 stalks; in a poor stand, 7000 to 9000 — a difference of about 3000 stalks, or a yield of more than thirty bushels. Probably the difference would never be so great, since a perfect stand rarely, if ever, occurs, but this example emphasizes the importance of good germination. It has been estimated that, in Iowa, the stand of corn has been increased fifteen to twenty per cent since the practice of making germination tests has been generally adopted by the farmers of that state. Thus several million bushels are added to the annual crop of the state.

Planting. — Corn is planted in rows usually three feet, six or eight inches apart. This space permits easy cultivation and gives the plants sufficient room.

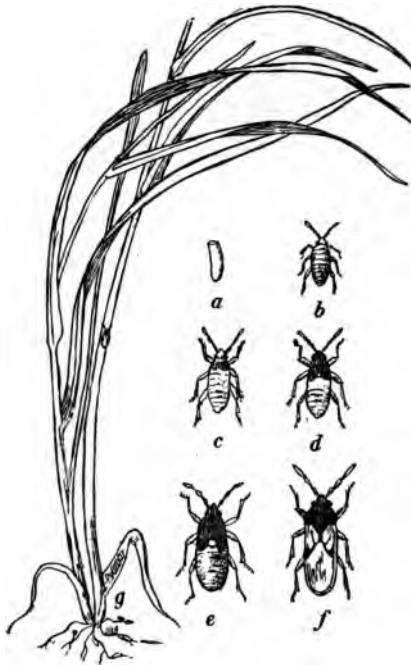
There are two ways of planting the rows: drilling, in which single grains are planted at about twelve inch intervals; the hill method, in which three or four grains are planted together in hills spaced to correspond to the distance between the rows. Both methods are so familiar that further details need not be given. The yield per acre of drilled corn is slightly greater than that of corn planted in hills. But this gain is sometimes offset by the greater ease with which weeds may be kept down in fields planted by the hill method, since cultivation may be done in two directions.

Cultivation. — If the seed bed is properly prepared, there will be a good mulch with which to start. The chief object of cultivation is to maintain this mulch in its original

effective condition. The first cultivation may be made with a harrow, for if care be taken, it does not injure the corn even though it has reached a height of three inches. Later, a cultivator adapted for such work should be used. The first cultivation may be rather deep. After that, by using a cultivator with small teeth the cultivation will be shallow enough to avoid injuring the roots of the plants.

The number of cultivations depends upon the season. Experiments have demonstrated that more than four for an entire season will not usually increase the yield.

During the early part of



Life-history of the chinch bug.

- a. Egg.
- b, c, d, e. Developing stages.
- f. Adult.
- g. Eggs at base of leaf of plant. (Hase-man, Missouri Agr. Exp. Station.)

the season it is desirable to cultivate after each rain as soon as the condition of the soil permits. Where a good mulch is maintained by frequent cultivation weeds are incidentally kept under control. In rainy seasons, the pre-

vention of weeds may become the chief object of cultivation.

Insect injuries.— At various times during the growing season corn may be injured by a number of different insects. Cut worms, white grubs, corn-root lice, and chinch bugs are usually the most destructive.

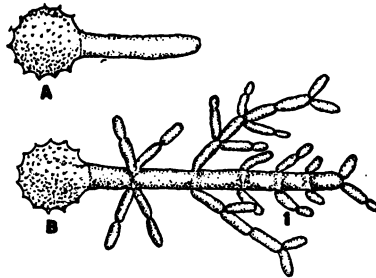
Cut worms are most dangerous to the very young plants. It has been found that fall plowing and late spring planting reduce the injuries caused by these insects. They are likely to be more numerous in land prepared from old grass sod. If such land is used for corn, extra precautions must be taken against cut worms. To a certain extent, these insects may be controlled by allowing corn to follow a legume, such as clover, in a rotation.

White grubs, the larvae of May beetles, are troublesome at times. The same methods of control may be used as those applied to the control of cut worms.

In some sections the corn-root lice are very destructive. It has been found that fall plowing is the best means of control.

Chinch bugs are not very injurious except in seasons when there is little rain. It is the habit of these insects to seek grass or other vegetation in which to spend the winter. By burning such material in the fall the danger of injury from chinch bugs may be much reduced.

Other insects, such as wire worms, corn-stalk borers,



Development of a spore of corn smut.

A. Smut spore germinating.

B. After germinating, numerous bodies known as conidia appear. These bodies act as spores which may infect a corn plant producing what is commonly called corn smut.

corn-leaf beetles, and corn-ear worms may at times prove destructive. Space will not permit a detailed discussion of them. Consult Chapter XVII which is a general account of insects as related to agriculture.

Diseases of corn. — Corn is not subject to many diseases. Its most common disease is corn smut, for which no direct remedy of practical value has yet been found. Fortunately, comparatively few plants in a field are infected with smut. The spores of corn smut remain in the ground over winter, germinate in the spring and develop chains of new spores. These new spores, being blown about by the wind, may infect any part of the corn plant with which they come into contact. There are two ways suggested for reducing the damage to corn by smut: first, to destroy the smut balls before they open to scatter spores; second, to rotate corn with other crops. Furthermore, seed selected from vigorous plants situated in areas free from smut will likely produce plants resistant to this disease.

Another disease now being carefully investigated is corn-root rot. It is important not only because of its injury in infected fields to corn plants, but because the same organism that produces corn-root rot also causes a disease of wheat and some other cereals, known as wheat scab. A discussion of plant diseases and their control will be found in Chapter XV.

How to get seed corn ready for the next year. — Attention has been called to the fact that seed corn selected from the crib is likely to prove unsatisfactory, especially in its low percentage of germination. The selection of seed corn is an important matter. It should begin in the field before the corn is harvested. The following is one method of seed selection: Search the field for the best plants, taking into consideration the entire plant, including the ear, and

mark a number of them. At husking time the ears from the marked plants should be kept separate. In case the corn is not to be husked soon after maturity, the best ears of the marked plants should be gathered at this time.

As soon as the corn is brought from the field it should be stored in a dry place. In order to secure a free circulation of air around each ear, the ears should be arranged in such a way as not to touch each other. After the corn is thoroughly dry, it may be stored in metal containers where it will be protected from moisture and from rats and mice.

If the plan of selecting seed corn in the field is followed year after year, it generally results in establishing a high-yielding strain. This plan is known as mass selection. A plan giving quicker results will be considered in the chapter on Plant Improvement.

In this connection attention should be called to the desirability of studying the points of corn so as to be able to make a good seed selection. Practice in corn judging is important since it develops an appreciation of a good ear of corn. Score cards for judging corn may be obtained from the State Agricultural College.

Harvesting.—The methods of harvesting corn are so familiar that only a brief reference, by way of summary, need be made. There are four general methods.

First, cutting and shocking: The best time for this operation is when the grain has hardened, but before frost. At this time the crop has its greatest feeding value, taking into consideration both fodder and grain. The usual method is to allow one shock for each square of sixteen feet. Where shocks are exposed to the weather there is a considerable loss in the feeding value of the fodder. The corn may be hauled to barns and shredded. In this way the loss oc-

casioned by weathering may be prevented, and at the same time, the material is put in a form to be more readily and completely used in feeding. Where many animals are to be fed, the gain in feeding material will more than equal the additional expense. Besides, the inconvenience of subsequent handling, especially in cold weather, is avoided.

Second, husking in the field: This work may extend over a period beginning with the hardened grain and lasting until after frost. Later the standing stalks may be utilized for feeding cattle or other farm animals. If it is so used, there is a much greater waste of fodder than when it is shredded. It is estimated that 25 per cent of the protein, and 37 per cent of the entire digestible nutrients of the corn plant are in the stalks and leaves. This fact should be considered in handling corn crops for profitable feeding.

Third, silage: If corn is to be extensively fed, to cattle especially, the method of preserving corn in a silo has many advantages. There is less loss of feeding material; animals relish it better than corn harvested in any other way; it is as easily handled as shredded fodder. It should be harvested before frost, when the grain is well glazed and beginning to harden. At this point the total digestible matter is about 20 per cent greater than when the corn is fully ripe.

The principle of making silage is simple. The silo itself is preferably a tall, air-tight cylinder ten to twenty feet in diameter, twenty to forty feet in height. The size depends somewhat upon the average number of animals to be fed. It is essential that a layer of at least three inches be removed each day after feeding is begun, otherwise some of the top layer will spoil. The inside walls of the silo should be perfectly smooth, in order that the contents may be thoroughly packed to exclude air. A special machine, or silage cutter, is neces-

sary to cut the corn into short lengths. When cut, the fine material is conveyed, usually by means of a blower, to the open end of the silo. During the process of filling the silo, the material should be packed by tramping, the area next to the wall receiving particular attention. By thorough packing as much air as possible will be crowded out. If the fodder is dry, as sometimes happens when it is cut after frost, enough water must be added to enable the mass to become well packed. As the silo is being filled, the weight of the silage material tends to make the mass more compact. For this reason, tall silos are to be preferred to short ones. After the filling is completed, certain processes of fermentation take place in which most of the oxygen of the enclosed air is used up. The products of this fermentation prevent further decomposition of the silage, except at the surface where it is in contact with air. The principle observed in preserving silage is similar to that used in making sauer kraut; that is, such conditions are created that the products of partial fermentation will prevent further decomposition.

Fourth, allowing animals to do their own harvesting: This method of harvesting applies especially to the use of hogs for this purpose. The hogs are turned into a field to remain until they have eaten all the corn. This plan, known as "hogging corn," has some advantages: it saves labor; it wastes little feed; and all the animal wastes are distributed over the field, thus adding to its fertility.

Distribution of labor in raising a crop of corn. — In the following tabulation, the labor required for the various operations pertaining to raising an acre of corn is indicated in terms of hours. These figures are averages taken from a study of a number of Ohio farms.

nature of the soil, the labor required will be greater than in others, but it is important that harrowing and disking be continued until the soil is well prepared.

Fertilizing. — The best fertilizer for corn is stable manure applied early enough to become well rotted before the crop is put in. The practice of spreading the manure in the winter while the ground is frozen is a good one for the Northern States. The manure adds nitrogen to the soil and promotes good conditions in the way already described. Manure should be balanced by the addition of phosphate of some kind and a small amount of potash. Most soils have in store a considerable amount of potash. In such cases only enough need be added to supply the plants during their early growing period, the time when they need it most, for the soil furnishes the rest.

There are several ways of applying a fertilizer that are in common practice. The method already considered, that of spreading a mixture of rock phosphate or acid phosphate and manure, will provide most of the phosphoric acid needed. A light dressing of acid phosphate and potash spread over the ground and worked in with a harrow, will complete the ordinary fertilizer requirements for corn. In this way there will be plenty of available nitrogen, phosphorus, and potassium for the young plants, and an abundant supply in store to be drawn upon later, as it is needed. Some farmers fertilize heavily for a crop, such as wheat, in a rotation with corn. The residue from this application remains to be used later by the corn.

Seed selection. — The use of good seed corn is quite essential for production, but is a matter much neglected. Too often, just before planting time, a selection is hastily made from the crib, with a poor stand and inferior crop as a

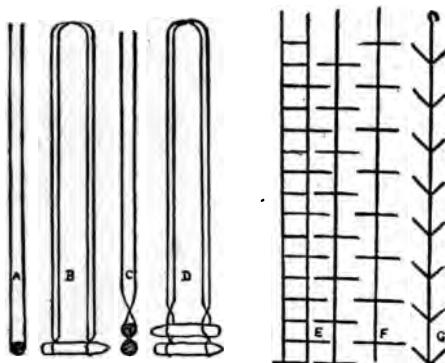
result. It takes just as much work to get the land ready, to plant, and to cultivate a poor crop as it does a good one. Therefore, there is a clear gain in using seed corn of a high-producing strain, having perfect germination when tested. It is not uncommon to find on neighboring farms fields of the same kind of soil, which have had equal care in preparation of the land and cultivation of the crop, showing a marked difference in

yield in favor of the one where careful attention was given to the selection and testing of the seed. The only sure means of knowing whether seed corn will make a good stand is to make a test for germination. The

value of making such tests on a large scale was emphasized in the spring of 1918. Because corn of the pre-

vious season had failed to mature, there was an almost universal shortage of seed corn throughout the Corn Belt. Extravagant prices were paid for corn that would germinate although it was inferior in other particulars. Those farmers who planted corn selected from the crib as usual failed entirely to get a stand. While other farmers, who planted only seed showing a high percentage of germination in the test, had no trouble whatever.

Corn intended for seed should be carefully inspected, ear



Two methods of holding ears of corn to dry for seed.

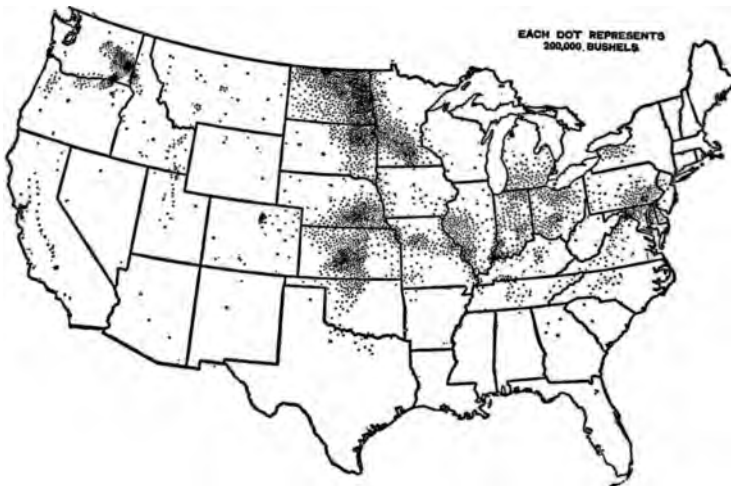
A, B, C, D.—steps in making a sling for corn ears from binder twine.

E, F, G.—steps in making a seed corn rack from a piece of woven-wire fencing material.

sideration in making such decisions. It should be supplemented by a careful study of local experience as to success or failure in producing small grain crops.

WHEAT

Climate. — The map showing distribution of wheat marks three rather distinct areas of high production. Climatic



Distribution map of wheat. One dot represents 200,000 bushels.
(U. S. Dept. of Agriculture.)

influences alone will not account for this distribution since these areas have quite different climates.

The first area, which includes the states of the Corn Belt, has rather mild winters and abundant rainfall.

The second, which is the Great Wheat Belt, lies between the western boundary of the first area and the Rocky Mountains. It includes the five great wheat-producing states, Kansas, Nebraska, South Dakota, North Dakota,

and Minnesota. In this region the rainfall is low and summers dry and hot, conditions favorable for production of hard wheat — spring wheat north of Nebraska, and winter wheat in the remaining states. In the Wheat Belt the average yield per acre is low, but the acreage is so great that nearly half of the wheat crop of the entire country is produced here. Extensive wheat farming is made possible by long stretches of level, comparatively cheap land.

The third area, which includes the Pacific States, is naturally adapted in many places to wheat growing. Here the winters are mild, the springs wet, and the summers dry. These conditions are favorable for a large production of the soft varieties of wheat. In this region, the high yield per acre makes wheat a profitable crop, even on rather high-priced land.

Soil. — Well-drained loam and clay loam are the soils best suited to the production of wheat. Sandy soils are generally too coarse to retain sufficient moisture, and heavy soils are too compact to allow aëration and drainage. Wheat is said to be a “delicate feeder”; that is, its plant-food material must be readily available. For example, organic matter should be well decomposed.

Relation of wheat to a system of farming. — From the foregoing discussion it is seen that wheat may be grown in nearly every section of the country. The demand for wheat, imposed by the Great War, extended the wheat acreage into many places that were formerly devoted to other crops. The use of wheat as a farm crop is not so much a question of whether it will grow well, as it is whether it will contribute to the profits of the farm.

The cost of raising a bushel of wheat, in 1909, has been estimated as fifty-five cents for the Pacific Coast region,

sixty-four cents for the Great Wheat Belt, and eighty-one cents for the Corn Belt. Although the cost is greater now, these relations are doubtless much the same. Owing to greater cost of production the farmers of the Corn Belt cannot compete in wheat raising with the farmers of the other two regions, unless the difference may be balanced by some other gain.

In the two latter regions wheat is the main crop. In the former it is a secondary crop used in rotation with other crops and is not expected to contribute directly to farm profits.

Wheat raising to be profitable in the Great Wheat Belt must be conducted on an extensive scale. The acreage must be large, though a smaller acreage might yield a profit if more attention were given to the preparation of the soil for seed. It is a question how long continuous cropping, which is generally practiced, may be continued profitably. In the wheat-growing sections of California, where continuous cropping has been practiced for many years, the yield has decreased greatly. Such experience seems to indicate the danger of this practice. Referring to California, a wheat expert says: "The general effect of the past and present methods has been the development of poor physical condition of the land, largely the result of depleted humus, until the soil refuses to produce profitable crops of the commonly grown varieties of wheat under the old system of farming, and besides, the soil has been made foul with weeds."

The solution of this difficulty is one in which farmers engaged in wheat growing should be interested. The methods suggested by the California Agricultural Experiment Station offer a good solution and apply not only to California, but to the entire Pacific, Western, and Northern wheat regions. The essentials of these methods are restoration of the

humus by green manure crops such as rye and legumes; deep plowing followed immediately by sub-packing the soil (by using the disk set nearly straight or, in light soils, by using a sub-surface packer); and thorough preparation of the seed bed. The success of these measures is seen by comparing the average yield of 14.5 bushels per acre for the entire state of California with 33.7 to 57.3 bushels on sandy soils, and 43 to 48 bushels on heavy soils, where this practice was followed.

In the Corn Belt wheat is generally a secondary crop. It is used in rotation, in part, to provide a cash crop, and in part, to secure a stand of clover. It is a common practice to sow wheat in the early fall between rows of corn. This method saves labor. It gives good results when a good mulch, a fine seed bed and freedom from weeds have been secured by thorough cultivation during the growing season. Because the maturing corn crop removes plant food from the soil a light application of a complete fertilizer will be needed to give the young wheat plants a good start. Instead of a light application of a complete fertilizer many wheat growers prefer a heavy application of acid phosphate alone. This practice is based upon the fact that wheat requires for a high yield a liberal supply of phosphorus. The place of rotation will depend upon the cropping plan for the farm. It is valuable as a nurse crop for clover, affording an easy way to secure a good stand. The straw is of considerable value for feeding live stock. At the same time it will make some return for the use of the land. Its relation to other crops should be such that the care of the wheat will not interfere with other work during harvest time.

Seed.— The first consideration is to select the kind and variety of wheat best adapted to the region in which it is

to be grown. It is advisable to follow the advice of the State Agricultural Experiment Station and the experience of successful wheat growers of the region.

Next in importance to variety is the quality of seed. The grains should be sound, plump, and free from impurities. Small grains are not objectionable. Experiments have shown



Types of hard wheat.

1. Fife. 2. Bluestem 3. Turkey 4. Durum
(U. S. Dept. of Agriculture.)

that the size of the seed has little or no effect upon the yield or quality of the next crop.

If smut infection is suspected the seed should be treated as follows: with a one per cent solution of formaldehyde for bunt or stinking smut; or with water heated to 130 degrees F. for loose smut. The details of the hot-water method are as follows:

1. Soak the grain four or five hours in cold water.
2. Place about one-half peck of the grain in a bag, or basket,

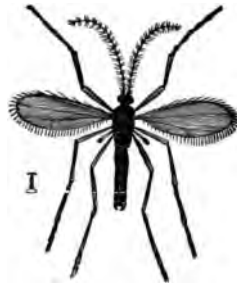
and immerse in water at a temperature of from 110° to 120° F. for about a minute.

3. Plunge wheat into water at 129° F., and barley into water at 126° F., and allow to remain ten minutes. Movement upward and downward while in the water will facilitate the penetration of the heat.

4. Immerse in cold water to complete the treatment.

5. Spread the grain out in order that it may dry quickly.

Preparation of the seed bed. — The methods of preparing the seed bed, already suggested for California wheat growers, have a general application. In the Wheat and Corn Belts, if the soil is plowed early enough to become well settled before planting time, it will be sufficiently sub-packed for winter wheat. A compact seed bed is of great importance, not only because it encourages root development, but it also tends to prevent winter killing.



HESSIAN FLY

Magnified

Time of planting. — Winter wheat should be sown in time to allow the plants to get well started before winter. Spring wheat should be sown as early as possible in order to secure a good root development before warm weather, and to permit an early harvest.

Diseases and insects. — Smut must be controlled by treatment of the seed. Rust may be controlled through rotation of crops or by use of rust-resisting varieties.

Another but less known disease is wheat scab. Injuries due to this disease seem to be increasing, the loss for 1920 being estimated at 20,000,000 bushels. The disease is caused by the same parasitic fungus that produces corn-root rot.

Being an intercrop disease it is especially dangerous, particularly in regions where the practice of sowing wheat in corn is followed. Its effects are more like blight than scab. All parts of the wheat plant may be attacked. The disease may be recognized by the "slightly brown and water soaked spots" on the wheat head. These areas rapidly spread over the entire head and often in damp weather to other heads. Kernels of infected heads are generally small in size and very light, making it possible to separate them from the rest of the grain by rescreening. While no complete methods of control have as yet been devised, two practices are suggested: one, the use of disease-free seed on uninfected soil; the other, avoiding a crop rotation in which wheat follows corn infected with corn-root rot.

The Hessian fly and chinch bug are the only insect enemies of wheat that may be controlled to any extent. The Hessian fly may be controlled by early plowing and late sowing. Since chinch bugs winter in stubble, weeds and grass, the remedy lies in removing, by plowing and burning, every thing that might afford winter protection for them. Especial attention should be given to weeds along fence rows adjacent to wheat fields. The Hessian fly prefers warm, moist weather. The chinch bug, on the other hand, thrives only in hot, dry seasons.

Harvesting. — In humid climates wheat should be harvested before becoming over-ripe. Otherwise the grain would be likely to shatter. Its milling value would also be reduced because over-ripe grain is not uniform.

After cutting, the bundles or sheaves are placed in loose shocks. The shocks are usually capped by spreading over the top two bundles at right angles to each other. After this operation, the wheat is likely to deteriorate, especially

in rainy weather. To avoid deterioration, when there is a long wait for a threshing machine, for instance, the wheat is sometimes taken from shocks and stacked. The extra labor involved is regarded by some farmers as less costly than possible losses.

In arid regions, such as the Pacific Coast, non-shattering varieties of wheat are grown and these are allowed to ripen fully. Here, a header — a machine which removes the heads only — is frequently used for cutting. Sometimes on large ranches, cutting and threshing are performed in one operation.

Cost of wheat production. — The following is an estimate of the average cost of producing an acre of wheat in Indiana, in 1918:

Preparing the seed bed.....	\$3.25
Fertilizing.....	2.25
Seed.....	3.75
Seeding.....	0.80
Harvesting.....	1.50
Threshing.....	2.00
Marketing.....	0.75
Use of land.....	5.50
Total.....	<hr/> \$19.80

The prices of the items in the above tabulation are high because of war conditions. The cost of wheat production varies from year to year. This illustration merely indicates the various items to be considered in estimating the cost of producing an acre of wheat. This will become lower as prices for labor, fertilizer, seed, twine, etc. are reduced.

This estimate is, doubtless, nearly correct for the other states of the Corn Belt. In the states of the Wheat Belt and

of the Pacific Coast region the cost per acre, based upon the estimates for previous years, would range from \$12 to \$15. The chief items of difference in expense between these regions and those of the Corn Belt are cost of fertilizers and the use of the land.

The rate of sowing, as indicated by careful experiments, ranges from eight to nine pecks per acre on heavy clay soils, and from four to six pecks on light soils. The rate seems to depend largely on the tendency of plants to stool or tiller. Where plants tiller but little, as in heavy soils, more seed is needed.

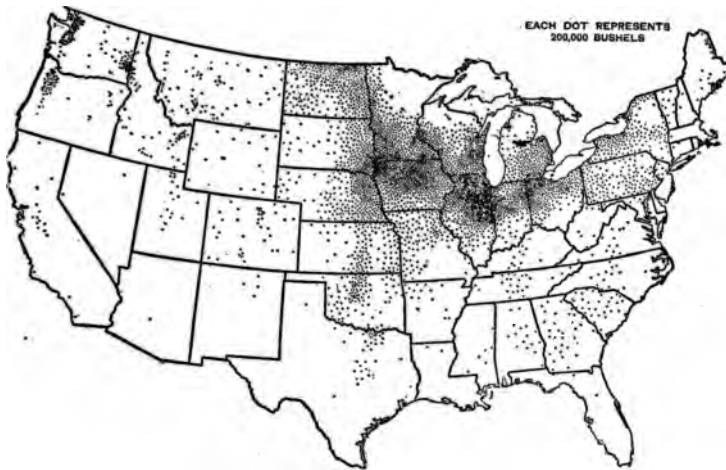
Fertilizers.—In the older farming regions, such as the Corn Belt, the use of manure and some form of phosphate, usually acid phosphate, is generally recommended by State Agricultural Experiment Stations. It has been estimated that the use of fertilizers for the crop of 1918, by all the wheat growers of Indiana, would have increased the average yield per acre from 19.5 bushels to 25 bushels. Such an increase would have been worth more than \$29,000,000 to the farmers of that state.

OATS

The map of distribution shows that oats are grown in most states of the Union, but that more than half of the crop is produced in the states of the Corn Belt, with Illinois and Iowa in the lead. The large production in these states may be explained by the common practice of using oats to follow corn in a rotation.

There are more than 400 varieties of oats. They differ in many ways: in shape of head, which may range from widely spreading to closely compact; in color of grain, which may range from white to black and include red, yellow and

gray; in hardiness, spring and winter oats; in time of maturity, early — which have a short growing period, late — which have a long growing season. From an agricultural standpoint the value of a variety depends upon its percentage of kernel, its yield, and its weight per bushel. In order to secure these desirable properties oats must have the



Distribution map of oats. One dot represents 200,000 bushels.
(U.S. Dept. of Agriculture.)

qualities of hardiness, earliness, stiffness of straw, and resistance to heat, drought and rust.

Climate and soil. — Oats are naturally adapted to a cool, moist climate. The ideal climate is one affording plenty of moisture, which is sufficiently cool to insure a slow ripening period.

Oats will do well on almost any tillable soil, but if the soil is too rich, the plants are likely to lodge.. Since the chief soil requirement for oats is moisture, clay soils are better than light soils.

System of farming. — Some farmers prefer a rotation in which corn is followed by oats instead of wheat. The small amount of labor required for putting in the crop, and the value of the straw and grain are perhaps the chief reasons for such preference. Oats, when not too thick upon the ground, make a good nurse crop for clover or alfalfa. The following rotations have been suggested by a good authority: For sections especially adapted to corn — corn, two years —



Types of oats — four varieties. (U.S. Dept. of Agriculture.)

oats, one year — timothy and clover one to three years; for Southern States — corn and cowpeas, one year — oats followed by cowpeas harvested for hay one year — cotton, one or two years.

Seed. — The weight of grains, rather than the size, should be considered in selecting oats for seed. It has been found that heavy seed gives better production than light seed.

Seed bed. — Oats grow well in a shallow seed bed. Because of this characteristic the ground may be disked instead

of plowed unless the soil is very heavy or in poor condition. This practice is especially successful in the Corn Belt where oats follow corn in a rotation.

Planting. — Sometimes oats are sown broadcast and then harrowed in. But a better and more uniform stand is obtained by using a grain drill such as is used for wheat.

The rate of sowing is based upon the same principle as that used in wheat sowing — a heavy soil requires more seed because the tendency to stool or tiller is less. The amount of seed needed per acre ranges from six pecks on warm, light soils to three bushels or more on heavy soils. When soils are in good condition, eight to ten pecks per acre seem to give the best results.

In the Northern States an early sowing is essential because cool, moist conditions are necessary for the best growth of oats. In the Southern States winter varieties are commonly used and are sown late in the fall, except in Kentucky and Tennessee where they are sown early in the fall. Here, spring oats are sown from one to two months earlier than in the North.

Diseases and insects. — Loose smut may be easily controlled by the hot-water method of treating the seed. It is always a safe practice to treat the seed with formaldehyde, as suggested for wheat infected with bunt. Rust is often a serious disease, especially on the Pacific Coast. Quick-maturing varieties sown early are least susceptible to this disease.

Insects are not sufficiently injurious to oats to require special measures for their control. The green bug, a plant louse, occasionally causes injury. If such is the case, the crop may be harvested early and used for hay.

Harvesting. — To secure the best yield of grain and the highest quality of straw, the oats should be cut in the dough

stage of the grain. At this stage the plants contain a large amount of moisture, therefore especial attention must be paid to thorough curing in the shock.

The general procedure for harvesting and threshing oats is the same as for wheat.

BARLEY

Although barley may be grown in a wider range of climate than any other cereal, it is produced extensively in five



Results of yield of oats from treated and untreated seed. Plants on the left were from seed that was treated with cresol. (Formaldehyde would have done as well.) Plants on the right were from untreated seed. (U.S. Dept. of Agriculture.)

states only: California, Minnesota, North Dakota, South Dakota and Wisconsin. The reason for this restricted production is largely an economic one. In the Corn Belt barley cannot compete with corn, but in states farther north where the growing season is too short for large corn production, it may do so. In California, barley is substituted for corn and oats because the two latter

do not thrive there.

The varieties of barley differ in several ways: the heads may have two, four, or six rows of grain and may be bearded or beardless; the hull may be present or absent; they may

be hardy enough to stand mild winters; the grain may be mealy or hard in quality.

If the grain is to be marketed, the choice of a variety depends upon the quality and yield; if it is to be used for feeding farm animals, upon straw and grain. If barley is to be used for hay, beardless varieties have an advantage; they are less irritating to the mouths of animals than the



Distribution map of barley. One dot represents 5000 acres.
(U.S. Dept. of Agriculture.)

bearded varieties. During the Great War, owing to the demand for wheat, barley flour became an important substitute for wheat flour. For such use the hard varieties are superior to mealy varieties because of their greater protein content. Much of the grain of barley was formerly used for brewing. The mealy varieties are generally preferred for this purpose.

Barley will do well in most parts of the country but it

thrives best in a rich well-drained loam. Much the same method is used for raising barley as for wheat.

When it is used for hay, barley is not threshed but is cut and cured like other kinds of hay. It is then stored in stacks under cover or in bales. In the Western States barley serves



Distribution map of rye. One dot represents 1000 acres.
(U.S. Dept. of Agriculture.)

a double purpose as feed for farm animals, especially for horses. It takes the place of both grain and hay.

RYE

Rye is the fifth in importance among cereals of the United States. It may be grown in most states, but thrives best in the North. It is much hardier than wheat, being capable of withstanding very severe winters. Although it thrives best on good soils, it will produce a fair crop on rather poor soils.

Because of the latter characteristic, it is frequently employed as green manure to build up poor soils, especially light sandy soils. If used for this purpose, it is usually sown in late fall and plowed under in late spring, thus allowing time to plant some other crop.

The selection of seed, the preparation of the seed bed and



Distribution map of rice. One dot represents 50,000 bushels.
(U.S. Dept. of Agriculture.)

method of harvesting are essentially the same as for wheat.

Rye straw is long and flexible and, when straight and unbroken, is in demand for packing and other purposes. Frequently a method of threshing is used which will remove the grain without breaking the straw. In some of the Eastern States the straw is of as much value as the grain. It sometimes commands as high a price as timothy hay.

RICE

In the United States, the region of greatest rice production lies in Southwestern Louisiana and Southeastern Texas. This region produces more than three-fourths of all the rice grown in this country. The rest is produced in four other regions: the Carolinas and Georgia; the bottom lands of Louisiana; the prairie region of Arkansas; and the great river valleys of California.

Rice growing has increased rapidly of late, especially since 1915. This increase may be explained in part by the demand for rice occasioned by the War; and in part because the land which is adapted to rice production is becoming more fully utilized.

During the four months of its growing season rice requires: a high temperature, not less than 75 degrees F.; an abundance of available water sufficient for irrigation during a period of about ninety days; level land with an impervious substratum near the surface to facilitate irrigation; and good drainage, to permit the rapid removal of water at harvest time.

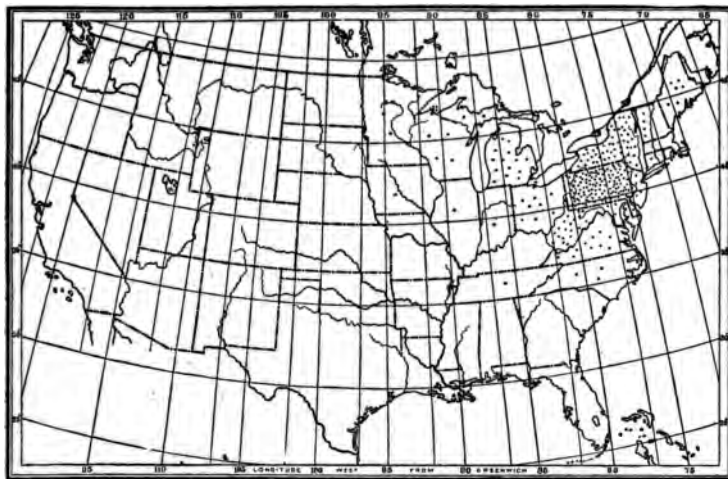
Aside from the use of water, the methods used in rice growing, from seeding to harvesting and threshing, are not very different from those followed in wheat growing.

BUCKWHEAT

Buckwheat is not a cereal but the same procedure for growing true cereals, such as wheat, answers for buckwheat.

The production of buckwheat is confined chiefly to the Northeastern States, New York and Pennsylvania furnishing the greatest production. It will grow in any temperate climate. It requires cool summer weather, with considerable rain, to produce a good yield of seed.

Outside of a rather limited region, where summer climate is favorable for seed production, buckwheat is grown chiefly for green manure, hay or forage. Its advantages as a crop for green manure are good growth on poor soils; rapid growth; its high percentage of nitrogen; its rapid decay when turned under. It is inferior as a hay crop because of



Distribution map of buckwheat. One dot represents 50,000 bushels.
(U.S. Dept. of Agriculture)

the difficulty in curing it, but it may be of some use when other crops have failed.

Sometimes small areas are planted to buckwheat for the use of bees. The flowering season is rather long and comes at a time when other honey-making flowers are scarce.

The time for sowing buckwheat may be adjusted to the demands of other farm work, because it requires so short a period to reach maturity — only sixty to seventy days. The procedure for growing and harvesting the crop is, in general, the same as for other cereals.

CHAPTER X

FORAGE CROPS

What forage crops are. — It may be that “forage” originally referred to those plants upon which animals fed in the fields or pastures, but now it generally includes all plants that furnish hay or rough feed as well as those used for grazing or pasture. Small grains and corn are sometimes used for forage, as, for example, straw of threshed grains; oats, barley and rye when used as pasture or fed entire; and corn when used as fodder, when shredded, or when used as silage. In the discussion to follow, forage crops will be considered in four groups; legumes, grasses, millets, and sorghums.

Forage crops are necessary in any system of farming which includes raising and feeding of animals. Fortunately there is a great variety of such plants that are available for this purpose. Some are adapted to one kind of climate, some to another, so that the production of forage crops is possible in most parts of the country. It remains for the farmer to make his choice of the ones best adapted to his particular region and system of farming.

LEGUMES

What legumes are. — It has already been necessary to refer to these plants several times in connection with soil fertility. The word legume is a botanical term which refers to plants that bear pods, such as peas and beans. Another

characteristic, common to all legumes, is the ability to form a sort of partnership with nitrogen-fixing bacteria, in which association nodules are formed on the roots.

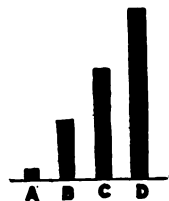
This close association with nitrogen-fixing bacteria may account for another very valuable characteristic of legumes — their power to make and to store up protein, an important substance in the feed of farm animals.

Value of legumes. — Legumes are almost necessary farm crops because of the characteristics mentioned. They enrich the soil by making possible the action of bacteria to convert the free nitrogen of the soil air into a form available for plants to use; and they furnish protein to balance the more starchy feed for farm animals, by manufacturing and storing large amounts of protein.

The value of these crops has long been known, but not until lately have they come to be regarded as essential to all except the most specialized kinds of farming. There is no crop that furnishes so much valuable feed for live stock and at the same time enriches the soil to such an extent.

Kinds of legumes. — The use of legumes is favored by the fact that there are many kinds adapted to different climatic conditions. There is no difficulty in finding a legume that will be reasonably productive in any section of the country, except perhaps in very cold regions.

In choosing a particular kind of legume its chief characteristics and requirements must be considered; such as



Effects of soil treatment on yield of alfalfa.

- A. No treatment.
- B. 4500 lbs. of limestone per acre.
- C. 4500 lbs. of limestone and 27,000 lbs. of manure per acre.
- D. Same as (C) but with addition of 300 lbs. of bone meal. Acid phosphate might have been substituted for bone meal with same results.

adaptation to climate, special soil requirements, methods of seeding, handling, etc.

The following list includes the most important legumes; clovers (including red, mammoth, white, alsike, crimson, and sweet), alfalfa, cowpeas, soy beans, vetch, Japan clover, peanuts, velvet beans.

Selection of a legume. — As has already been suggested the choice of a particular legume for a farm depends upon several factors. In general, the most important are climate, soil, and the system of farming to be used.

Climate. — Usually it will be a safe practice to use the legumes that are commonly grown in a region. For example, in the Corn Belt red clover is generally grown, and this legume would be a wise selection for that region.

Soil. — The soil should be well drained and furnished with plenty of lime. These are the two chief requirements of all legumes. Of course a rich, deep soil will produce a much greater yield than a shallow, poor soil.

Some legumes are less sensitive to soil conditions than others. For example, mammoth clover will often make a good yield on soils too poor for red clover. Alsike clover will grow on rather poorly drained soils. Sweet clover will generally grow on soils where other legumes fail. Cowpeas are adapted to a wide range of soils.

System of farming. — In the chapter on Crop Production, emphasis was placed upon the need of using legumes as a means of keeping up soil fertility. They are also needed for feed. The kind of legume raised is not so important as that a rotation should be established by which each cultivated area of the farm may become periodically enriched by legumes. The system of farming should cover both these purposes.

In the Corn Belt red clover generally fits well into a system of farming where animals are to be fed. In the South cowpeas, soy beans and velvet beans are commonly grown. Here especially the system of farming must include soil improvement. Cowpeas and velvet beans are well adapted for enriching the soil and also for feeding farm animals. If silage is to be made, soy beans or cowpeas fit well into the system. Silage made of either of these legumes and corn usually makes a better ration than a silage made of corn alone.

Raising the crop. — Each legume must be raised by the methods best suited to its particular needs. Space will not permit a detailed consideration of all these methods, but there are some general principles that apply to all legumes. These principles may be briefly summed up as follows: the soil should be as well drained as possible, and any acidity corrected by use of lime; the seed bed should be well prepared; the seed should have a high percentage of germination and be free from weed seeds; the harvesting should be timed to give the greatest yield of digestible nutrients; the method of harvesting should provide for thorough curing of the hay.

Red clover. — This legume is grown very generally throughout the states of the Corn Belt, and to some extent in most of the other states. The importance of clover is indicated by the statement made by the Illinois State Agricultural Experiment Station to farmers of Illinois "that the growing of clover on somewhere near one-fourth the tillable land is absolutely essential in the permanent maintenance of the productivity of the state."

The value of red clover lies in its ability to enrich the soil by fixation of nitrogen, its large root system penetrating the

soil deeply and promoting good aëration, and its high feeding value for all kinds of farm animals. Besides, being a biennial plant, it is well adapted for use in short rotations of crops.

For successful production of red clover there are three requirements that should be observed: favorable soil conditions, getting a good stand, and fall and winter treatment.

Favorable soil conditions include good drainage, enough lime to neutralize soil acids, phosphorus, and organic matter. Lack of any one of these will likely lead to failure.

Frequent causes of failure in growing red clover are poorly prepared seed bed, rank-growing nurse crop, and too heavily seeded nurse crop. Clover requires a good seed bed having a fine surface and firm sub-surface. The use of a corrugated roller immediately before or just after seeding is a good practice for it not only improves the seed bed for the clover but also for the small-grain nurse crop. Early maturing nurse crops, not too heavily seeded, seem to give the young clover plants the best start. Wheat because of its early harvest is regarded by many farmers as the most desirable nurse crop for clover.

By fall and winter treatment is meant protecting the clover that has become established from winter injury. Too late or too close pasturing in the fall will leave the ground bare and the young clover plants without winter protection. Sometimes there is a heavy growth in the fall. In such cases careful pasturing or clipping should be done to prevent over-development of the clover.

Clover for hay should be cut when about one-third of the heads have become brown so as to give the maximum yield of total dry matter and digestible nutrients.

Other clovers. — Mammoth clover is too coarse for the best

quality of hay. It is superior to red clover for renewing organic matter in depleted soils and less exacting in its requirements for good growth.

Sweet clover is not relished by farm animals, at least not until they are forced to acquire a taste for it. It may be used for hay or for grazing in emergencies due to shortage of other forage crops. Its chief value is its hardiness and ability to grow under unfavorable conditions. Its most important general use is to build soils, being especially useful on eroded surfaces or on so-called worn-out soils.

Japan clover (*Lespedeza*) is an annual clover that readily seeds itself. It is grown in most of the Southern States in pastures for grazing purposes. On account of its light yield it is not often used as a hay crop.

Alfalfa. — Alfalfa is a superior forage plant because of its high feeding value and large yield. As compared with red clover it contains 9 per cent more digestible dry matter and 4.6 per cent more digestible protein, and yields about twice as much green forage. As a soil builder it is also superior. It has a heavier and deeper root system than clover, making it possible for it to reach and use plant food at a great depth.

It will grow on a wide range of soils if conditions are favorable. These conditions are good drainage, sufficient lime, and presence of organic matter. All three of these conditions must be met for success in growing alfalfa.

Two methods are employed in getting a stand of alfalfa. Both require a well prepared seed bed — deeply plowed, well firmed and finely surfaced — and for most soils, inoculation. One method for getting a stand is spring seeding with a light nurse crop. The difficulty with this method lies in the control of weeds. They are not always kept down by the

nurse crop. The other method is late summer seeding. The advantage of this method is that it is often possible to use ground that has produced a crop during that season. When such a field is used it is desirable to make a liberal application of well-rotted manure and work it thoroughly into the seed bed. Some farmers follow the practice of summer fallowing, keeping down the weeds during the summer by frequent tillage.

Alfalfa is a perennial. It may be grown without renewal for many years. Five or six years usually cover the most productive period. Some farmers use alfalfa in a long rotation; others prefer to set aside a separate field so that the regular rotation of the farm will not be interfered with. It has been suggested that in growing alfalfa for the first time a farmer should begin with a small area — one or two acres — and gradually, as he gains experience, put additional land into alfalfa until his needs are satisfied.

Alfalfa should be cut when new shoots are appearing at the crown of the plant. Hay made at this time will have a much higher feeding value than if made from more mature plants.

Vetch. — Common vetch is grown for hay on the Pacific coast and in the Southern States. Hairy or Russian vetch is very hardy and can be grown in all parts of the country. It is frequently used after a failure to secure a stand of red clover. Some farmers sow it in their corn fields at the last cultivation for fall and early spring grazing, and for green manuring.

Cowpea, soy bean, velvet bean. — These plants are extensively grown in the Southern States chiefly as hay crops. Cowpeas and soy beans are generally grown in the Northern States for both forage and seed. The hay from all three plants has

much the same value as alfalfa hay. The seed is very rich in protein and is valuable for balancing starchy rations.

GRASSES

From an agricultural viewpoint, grasses may be considered as belonging to two groups, pasture grasses and meadow grasses. Either of these grasses may be used for pasture or may be cut and used for hay.

Pasture grasses. — This group includes our various native grasses. The best known is Kentucky blue grass. On the Western Plains there is a mixture of several kinds of native wild grasses, called prairie grass. Near the sea shore level areas are covered with several kinds of wild grasses collectively known as salt or marsh grass. On the Pacific slope various grasses, such as wild oats, furnish good pasture during the latter part of the rainy season and for some time afterward. Among the mountains occur level stretches, known as mountain meadows, that are covered with many kinds of grasses useful for pasturage. In all these sections native grasses provide valuable pasturage on land not under cultivation.

Pastures are of two kinds, permanent and temporary. Those parts of a farm that cannot be cultivated with profit, such as hill land, may become permanent pastures. In this way unused or waste land becomes productive. In the case of slopes and hillsides, the sod also serves as a protection against soil loss through erosion.

Temporary pastures are those grown in rotation with other crops. They are often a mixture of grasses and legumes and remain from one to three years, according to the system of rotation employed.

Meadow grasses. — Grasses are especially valuable for hay, because they dry easily when cut and are therefore easily preserved for stock feed. Although they do not have as great food value as legumes, they are much relished by stock.

Among the grasses used for hay, timothy has the first place, being adapted to the climatic conditions throughout

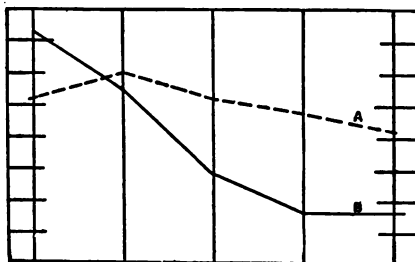


Diagram showing the relation of digestibility and yield of timothy hay to time of cutting.

A. Relative yields of dry matter at different stages.

B. Relative digestibility at different stages.
(Missouri Agr. Exp. Station.)

the Northeastern and Rocky Mountain States. In the Cotton Belt and in the Gulf States Johnson grass and Bermuda grass are grown for pasture and sometimes for hay.

Native grasses furnish the most important hay crops in the Plains Region. In the states of the Pacific Coast, grain hay, such as

barley, is chiefly used, although orchard grass, timothy, and other grasses are used to some extent.

The yield of hay from meadows tends to grow less from year to year, unless they are fertilized — a somewhat difficult practice seldom followed. On account of decreasing yields from old meadows, it is desirable to keep meadows in a system of rotation, leaving each field in grass only two or three years. For example, it is a good practice to sow a mixture of clover and timothy seed in the field the same year. During the first season clover will predominate, but will be replaced largely by timothy the second season, and

by the third season the field will be set to timothy. After that time the land is ready for a crop of another kind.

Grasses should be given the same attention as small-seeded legumes in regard to preparation of the seed bed, quality of seed, and sowing.

MILLETS

Millets are annual plants grown as the chief hay crop in the Central Western States. They are both heat and drought resistant and therefore are well adapted to this region. Owing to their short growing period, they are sometimes used in other sections of the country to furnish hay when the regular hay crops fail.

Among the most important kinds of millets are common or foxtail millet, German, and Hungarian millet. Broom corn and pearl millets are grown in some places.

Millets yield well when grown under favorable conditions. The procedure of seeding and handling the crop is similar to that followed for other grasses. The time of cutting, however, is especially important. Millet should be cut at that stage of growth when the blossoms appear. Late cutting



Varieties of Kafir.

A. White. B. Guinea.
C. Blackhull. D. Red. (U.S. Dept.
of Agriculture.)

should be avoided because the woody stems and hard seeds injure the quality of the hay.

SORGHUMS

Sorghums are grown chiefly in the Southern and Central Western States. They are used for grain, forage, and hay.

Kafir corn, milo maize, feterita, and durra are the kinds



Milo maize — an improved variety. (U.S. Dept. of Agriculture.)

most commonly grown. Sudan grass, related to the sorghums, has lately been introduced in the South and promises to be a valuable hay plant for this region. It is sometimes grown in the North, as in Wisconsin.

When grown for a hay crop, sorghums must be sown thickly to prevent too coarse a growth. The cutting should be done when the seeds of the plants are in the milk stage, so as to reduce the proportion of woody material in the hay. The method of curing and handling is similar to that employed in other hay crops.

CHAPTER XI

MISCELLANEOUS CROPS

IN the preceding chapters all of the staple farm crops except cotton have been discussed. But there are many other farm crops of agricultural value — too many to enumerate. They are included in the following great classes:

1. Fiber crops — cotton, flax, and hemp.
2. Tuber and root crops — potatoes, beets, and turnips.
3. Sugar crops — sugar beets and sugar cane.
4. Stimulant crops — tobacco, tea, and coffee.
5. Garden crops — including the common garden vegetables.
6. Orchard crops — including fruits and nuts.

A few examples from these classes will be discussed somewhat in detail. These examples are selected because of their agricultural importance in certain sections of the country, because of their value as a cash crop in general farming, or because of their value for home use.

Cotton, potatoes, tobacco, and factory crops (sugar beets, tomatoes, sweet corn and peas) will be discussed in this chapter. Garden and orchard crops are so valuable for home use on the farm that a separate chapter will be devoted to each.

COTTON

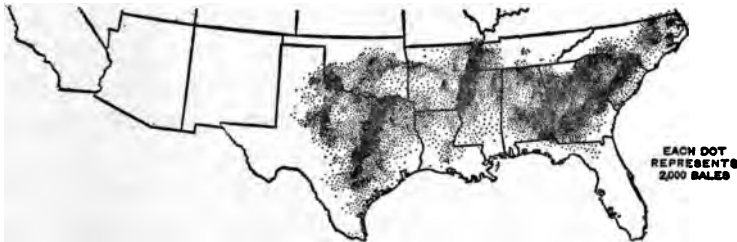
Cotton is adapted to the climate of the Southern States. Nearly half of the cotton crop of the world is produced here.

The region, known as the Cotton Belt, may be seen on the distribution map of cotton production. It is the leading crop of these states, and has become of national importance, because of the value of the production itself (it amounted, in 1915, to over \$600,000,000) and because of the great cotton-manufacturing industry which it supports. Cotton-seed products also add much to the value of the cotton crop, amounting, in 1915, to about \$180,000,000. Cotton-seed oil has about the same composition as olive oil and has similar uses; cotton-seed cake (the residue after the oil is expressed), because of its high protein content, is an excellent feed for farm animals; even the hulls of the cotton seed serve a variety of useful purposes.

The history of cotton growing in the South is similar to that of crop farming in the North. Cotton growing began in the Atlantic Coast States. Later, as land became less productive, it extended westward, finally reaching Texas and Oklahoma. Until recently, continuous cropping has been generally employed with a consequent loss of soil fertility, except where fertilizers are liberally used. The tendency toward low yield due to this practice, and the effect of the cotton boll-weevil and other insects, have made it necessary to modify the older methods. The new practice now being introduced makes cotton one of several crops in a rotation. It includes also restoration of the soil fertility by the use of legumes in the rotation and by the feeding of farm animals. The mild climate and abundant rainfall are favorable for the production of a large variety of forage crops. The use of these, together with cotton-seed products or some other protein feeding material, makes stock raising profitable. The kind of farming that includes a rotation of cotton with good feeding crops not only introduces a new source of profit, but,

at the same time, increases the yield of cotton per acre. The introduction of these new methods is a slow process, partly because of lack of capital, but chiefly because it is difficult to get farmers to change from a method with which they are familiar to an untried one.

The lack of capital is now being overcome by the operation of the Rural Loan Act which makes it possible for a farmer to obtain loans for equipment and live stock. To overcome the farmer's resistance to a change of methods, an educational program is being introduced. It will deal with adult farmers



Distribution map of cotton. (U.S. Dept. of Agriculture.)

through county agents and farm demonstrations, and with boys through club work and the public schools.

Cotton growing has lately been introduced into the irrigated regions of Arizona and Southern California. These regions are particularly well adapted for the production of a kind of cotton with a long staple or fiber. On account of its strength, this kind of cotton is in demand for the manufacture of rubber tires for automobiles.

Preparation of the seed bed and planting.—The usual time for plowing is February or March. Where cotton is grown successively on the same land fall plowing has several advantages; among them are a better control of the boll-

weevil and boll-worm, and the possible utilization of the cotton stalks as green manure. Fall plowing followed by the sowing of winter grain and crimson clover is also practiced. The grain and clover furnish forage for stock and, when turned under in the spring, improve the soil. Preparing the seed bed by means of ridging is the older and more common method. Two furrows are thrown together forming a ridge for each row. The ridge is made ready for planting by breaking with a double moldboard plow. A special machine may often do the planting and breaking at the same time. Since this method warms and drains the soil it is advantageous for wet and poorly drained soil.

The other method is similar to that used in preparing the seed bed for corn. This second method puts the seed bed in better condition and saves labor by making use of better farm implements.

Where continuous cropping is practiced, commercial fertilizers must be used either at the time of seeding or before the final preparation of the seed bed. Acid phosphate at the rate of two hundred pounds to the acre is commonly used.

Planting is done in drills, in rows spaced according to the richness of the soil—from two and one-half to five feet apart. The seed is drilled thickly, but the plants are afterwards thinned to a distance of one or two feet apart.

Cultivation.—The crop is cultivated in much the same way as any other cultivated field crop. The chief object is to keep down weeds. The control of weeds is easier with the level system of planting than with the ridge method, because the harrow or weeder can be used when the plants are very small.

Diseases and insects.—Cotton-wilt and cotton-root rot are the most common diseases. They are especially de-

structive when continuous cropping is followed. The rotation of crops is the most effective means of control.

The cotton boll-weevil is by far the most serious insect pest. Its range has gradually spread until it now includes most of the Cotton Belt. This insect may produce as many as five generations in one season. The first generation attacks the bolls when just forming.

The adult boll-weevil spends the winter as an adult, hiding in parts of the cotton plant or in other plant refuse left in the field. Fall plowing, the cleaning of fence rows and adjacent fields, and early planting of quick-maturing varieties of cotton seem to be the best means now employed in controlling this insect.



Boll-weevil — an adult insect. (U.S. Dept. of Agriculture.)



A cotton boll showing injury by larvæ of the boll-weevil. (U.S. Dept. of Agriculture.)

The boll-worm, the same insect known in other places as the corn-ear worm, does considerable damage to the cotton crop. It is controlled in the same way as the boll-weevil.

Harvesting. — Picking is done by hand. Beginning late in August, picking may extend over a period of three months. After the cotton is picked, it is taken to a gin which removes the seed from the lint. The lint is pressed into large bales which are made secure by straps of baling iron.

POTATOES

Value of the crop. — Potatoes are now regarded as almost a necessary part of our daily bill of fare. Besides, considerable quantities are used for stock feeding, starch making, and other purposes.

The production of potatoes for the entire country, in 1917, was estimated at 442,536,000 bushels, valued at \$543,865,000. For the five-year period of 1908-1912, the average production per acre was only 96.2 bushels. A much greater acre production is possible. In Utah, in 1916, 925 bushels were said to be produced by a boy, on one acre. In certain sections of Colorado 800 bushels per acre have been produced. Notwithstanding the possible large production of the potato crop, the actual needs of the country have at times required the importation of large quantities from foreign countries. A good illustration of the effect of low production may be cited. There was a shortage in 1916-1917, the production amounting to only 285,000,000 bushels. On account of the War no potatoes could be imported and the retail price reached as much as eight cents per pound — a price beyond the means of many people. A similar situation occurred in the spring of 1920, the retail price rising to ten cents per pound.

From this review of the agricultural importance of potato production, it is apparent that there should be at least sufficient production to supply the needs of the entire country, making importation from other countries unnecessary.

Potato growing has proved a profitable field for special farming in regions well adapted by soil and climate for this crop. Besides, in many places it is a source of profit as a cash crop in general farming and is also valuable for home

use. The production of potatoes in its relation to domestic consumption is low, and the possibility of large production with good financial returns is shown by the experience of many growers. Therefore, it is suggested that the growing of potatoes, as a special crop as well as an incidental crop, could be greatly increased with profit not only to the farmers concerned, but to the consumers as well.

There are two indirect benefits of potato growing that add to its value as a farm enterprise — the effect of a potato crop on the soil and on the control of weeds.

It has long been observed that various farm crops when grown on land previously used for potatoes show a greater yield than the average for such land. It is also necessary for the best success in growing potatoes to rotate them with other crops, preferably in a long rotation. Some crop should therefore follow potatoes each year. This crop will ordinarily be more productive than under the usual farm conditions of production.

In regard to the control of weeds, since potatoes must be well cultivated, the clearing of weeds from the land is assured.

In this connection one rather serious disadvantage of potato growing should be mentioned — it is not adapted to unusual seasonal conditions, such as too much or too little moisture. Under either of these conditions the crop is likely to be a failure.

Another point should be taken into consideration; during seasons that are unusually favorable over a wide territory, the production may be so great as to lower prices beyond the margin of profit. Doubtless this difficulty will in time be offset by the use of potatoes for other purposes than human food; for example, for starch making, production of alcohol for fuel, feed for hogs, etc. If potato production should

become great enough to supply material for these uses each year, in addition to providing the amount needed for table use, the problem of disposing of the surplus of unusually productive years would be solved.

Climate. — Potatoes require for their best growth a cool, even temperature. In the South, they may be grown only in early spring or late fall in order to escape tipburn, sunscald and other difficulties. In the irrigated regions, as in California, Utah, and Colorado, conditions are favorable, except that the cool nights are a slight disadvantage.

Outside of these states the climate best suited for potatoes is found in Maine, in parts of other New England States, also in New York, Michigan, Wisconsin, Minnesota, and North Dakota. As a special crop or as a cash crop the potato is not likely to prove satisfactory outside of these regions. In other sections early spring planting for summer use and summer market and fall planting for winter use should produce enough potatoes to supply the home needs and, in many instances, a surplus for sale.

Further requirements for potato production. — Aside from a favorable climate there are four requirements for the best success in growing potatoes; selection of suitable varieties, liberal fertilizing, thorough cultivation, and the control of insects and diseases.

In selecting potatoes for seed several things must be considered. Those varieties should be chosen which local experience has shown to be productive and at the same time to possess marketable qualities.

In the same field it is possible for one variety to produce abundantly with good market quality and another to produce heavy tops, with tubers of inferior yield and quality. Among the standard varieties are the Early Ohio, Early Rose, Bur-

bank, Irish Cobbler, Carmen No. 3, Rural New Yorker, Early Triumph, and Sir Walter Raleigh. Experience only can determine the most suitable variety for a given locality. The four-hill-unit method of improving potatoes described in Chapter XIV is well worth trying. In a few years a high-yielding strain adapted to local conditions may be developed in this way.

Individual tubers, to be used for seed, should have a smooth skin, shallow eyes, good shape, and should be free from evidence of disease, such as scab. Blocky, rather than long, pieces should be cut. Each piece should contain one or two eyes. The size of the piece is more important than the number



Potato tubers — the kind for initial selection in the four-hill-unit method of improving potatoes by selection.

of eyes. A one-ounce piece will furnish plenty of plant food to give the new plant a good start.

A sandy loam underlaid with clay is regarded as the best soil for potatoes. It should be moderately rich, especially in organic matter, for the double purpose of providing good soil conditions and plant-food material. The soil should be kept in good condition by rotating the potatoes with legumes and the frequent use of green manure. Other fertilizers are also needed, especially potash, and some phosphoric acid. The potash and phosphoric acid requirements may be met by using a heavy application of manure reinforced by acid phosphate.

The best possible preparation of the seed bed should be made for all crops, but deep plowing is especially important in potato growing. The plowing should be followed by thorough cultivation, deep at first, but shallow in all the later cultivations, because the potato roots grow near the surface of the soil. Ridging, or hilling, is not necessary, except just enough to protect the tubers from sunburn.

The control of injurious insects, such as the Colorado potato beetle, and of diseases, such as late blight, requires considerable attention. With all the conditions of climate, soil, variety, and cultivation favorable, it is possible to have a crop failure because of a failure to control either insects or diseases. Fortunately, control of these two factors is possible although it requires labor and some expense.

The general procedure is as follows: to destroy the spores of such diseases as potato scab, brown rot, black leg, stem rot, etc., the seed tubers should be treated, before planting, with a solution of formaldehyde (made by adding one pint of formaldehyde to thirty gallons of water) or with a solution of corrosive sublimate (four ounces of corrosive sublimate to thirty gallons of water).

During the growing season in order to control blight and other diseases, the plants should be sprayed from time to time with a Bordeaux mixture (5-5-50 strength); to control insects a mixture containing arsenic, such as Paris green or arsenate of lead, should be used.

Details for the preparation of these mixtures, and the methods and time for their application will be found in the appendix.

If possible only those tubers free from diseases should be used as seed. The seed should be planted in clean land. A long rotation should be practiced, because if soil is once

infected by such diseases as scab, it remains infected for several years.

Harvesting. — Potatoes may be harvested any time after the tubers have matured; but early crops are often harvested before maturity in order to meet the summer market.

Any method may be used which will get the tubers out of the ground without injury. Methods vary, from the use of a potato-fork or hook by hand on small areas, to the use of special digging machines, such as potato elevators, on large fields.

TOBACCO

Since pioneer times tobacco has been of an agricultural importance. The success of tobacco growing depends more upon the soil conditions and management of the crop than upon climate. In a number of states natural soil conditions, here and there, are favorable for the successful production of this crop. The range of tobacco may be seen by noting the position of the nine tobacco-growing states: Kentucky, North Carolina, Virginia, Ohio, Connecticut, Tennessee, Pennsylvania, South Carolina, and Wisconsin. Fourteen other states produce it in considerable quantities. The total farm value for the entire country, for 1915, was \$96,041,000.

The soil requirements vary with the kind of tobacco grown. In general, the mild, light, thin-leaf types, such as cigar-leaf tobacco, are produced on light sandy loams; while strong, dark, heavy types are grown on sandy clay loam. Tobacco is said to be "hard on land," which means that the crops that follow do not yield well. This statement does not apply to well-managed farms where the succeeding crop is better than the average on the rest of the farm. But rotation must be practiced, for continuous cropping of tobacco

will not succeed. Fertilizers are often used, especially those containing phosphoric acid and potash.

Tobacco is grown as a cash crop and in some localities as a main crop. Where it is produced along with other crops in general farming, there is a tendency to make tobacco the main crop to the neglect of other crops. This tendency is to be deplored; for the additional profit gained from the tobacco would doubtless be more than equalled by the profit secured from a well-balanced system of farming.

The production of a tobacco crop is too complicated a procedure to discuss in detail here. Many of the operations require special skill and experience.

Factory crops. — Included in these are sugar beets, tomatoes, sweet corn, peas, and cucumbers. According to the general practice, these crops are produced in coöperation with factories. Beet-sugar factories and canning factories enter into contracts with the farmers to buy certain products. The factories give directions for planting and caring for the crops, sometimes furnishing expert supervision and often furnishing seed. As the factory crops require considerable labor, the average farmer can devote only a part of his farm to their cultivation; but where factories are near, such crops are often useful as cash crops, and on small farms they may become the chief source of income.

CHAPTER XII

USE AND CARE OF THE FARM GARDEN

Place of the vegetable garden on the farm. — The production of vegetables for home use is often neglected by the farmer. It is hard to believe that one whose business is producing crops should depend upon the village market instead of supplying his table from his own garden. Nevertheless such a practice is not uncommon. The farmer seems to dislike the care of a garden. It seems trivial work to him, and he believes that it is cheaper and less trouble to buy table vegetables than to produce them.

In some instances this attitude may be justified, as in regions where there is little summer rainfall. But on most farms a vegetable garden will give ample returns for all the labor spent upon it. It should supply a variety of fresh vegetables in season and produce surplus enough to be preserved for winter use.

Requirements for a farm garden. — Three factors are essential to the success of a farm garden: First, the plot should be small enough to prevent its proper care becoming a burden; second, the soil should be reinforced by a heavy application of well-rotted manure and then put into the best possible condition; third, a careful plan should be made well in advance, so as to provide for a variety and succession of vegetables sufficient for all home needs.

If the soil is carefully fertilized, a small plot, well-planned, will meet all the requirements of the average farm home.

If it is plowed in the fall and a liberal amount of well-rotted manure is then applied, the work necessary to put the soil in good condition in the spring will be much reduced. Besides, the organic matter added will tend to retain moisture and make the soil easy to work during the growing season.

After this initial preparation of a garden plot has been made, a rotation may be established which will meet the soil requirements of the various vegetables, and, at the same time, reduce the amount of manure to be applied in any one year. Such a plan is sometimes known as the "three-field system." It is based upon the fact that vegetables may be divided into three groups, according to the richness of the soil needed for their best development. The first group requires heavily-fertilized soil. This group includes plants used for their tops or fruits, such as cabbage, lettuce, tomatoes, and corn. The second group requires soil of moderate fertility and includes the root crops, such as potatoes, turnips, radishes, carrots, etc. The third group requires no fertilizer unless the soil is very poor. Peas and beans belong to the third group. Being legumes, they can supply their own nitrogen.

The three-field system is carried out as follows: The garden area is divided into three parts; the first is richly fertilized with manure balanced with acid phosphate; the second is sparingly fertilized with finely divided, well-rotted manure; the third is left unfertilized. On the first division are grown plants of the first group; on the second, plants of the second group; on the third, plants of the third group. In the second year, the division which, during the first year, bore plants of the first group, is planted to plants of the second group, and in the third year to plants of the third group. In the fourth year, as in the first year, it is richly fertilized and planted to plants of the first group. The division which,

during the first year, bore plants of the second group is planted the second year to plants of the third group, and so on. Thus by rotating crops, the three divisions may indefinitely be kept in a condition best adapted to each of these three groups of plants.

Another method that has been used with good results is to rotate garden crops with some legume, such as clover. This plan has two advantages. It gives the land a rest every third year and it increases the supply of humus and nitrogen in the soil.

The method is as follows: The garden is divided into three equal parts; for the first year clover is sown on part 1 and vegetables on 2 and 3; for the second year, clover is sown on part 2, vegetables on 1 and 3; the third year, clover is sown on part 3, vegetables on 1 and 2. This completes the rotation which is then repeated.

It will be a simple matter to get the garden started if a detailed plan is made and seed procured during the winter when there is plenty of time not needed for other farm work. During part of the winter months it might be well to have the class in agriculture make a planting plan for the garden, each pupil constructing a plan for his own home garden.

There are two steps in making such a plan. First, the plot should be drawn to scale from actual measurements of the area of ground to be used, each foot represented by a fraction of an inch on the drawing. For example, a plot 80 by 160 feet, represented on a sheet of paper with a scale of one-eighth of an inch to a foot, would make a rectangle ten by twenty inches; a distance of three feet between rows would be indicated by a space three times $\frac{1}{8}$, or $\frac{3}{8}$ of an inch.

After the exact area of the garden has been drawn to

scale, the accurate positions of all the vegetables to be planted may be fixed and the time of planting of each may be indicated.

If the plan is for the three-field system, the proper placing of the vegetables belonging to each group should be indicated. A planting table giving the time of planting and other details of our common vegetables should be consulted.

It is especially important to arrange the planting plan to secure variety and succession. A quantity sufficient to supply all needs may thus be provided without the over supply that frequently occurs in a poorly planned farm garden.

Care and protection. — By planting the vegetables in rows far enough apart to permit the use of a field cultivator, hand labor may be reduced to a minimum. The hoe and rake will be needed only for those parts not reached by the cultivator. Experience has shown that thorough cultivation increases both the yield and the quality of garden vegetables.

Plant diseases and insects are apt to do much harm unless measures are taken for their control. The number of diseases and insects that attack garden plants is too large to be considered here. The details of a means of control will be found in the references suggested in another paragraph.

Sources of information. — Space does not permit further directions for planting or managing a garden but they may be found in references given in the appendix. The conditions brought on by the Great War, in the spring of 1917, aroused an interest in gardening never before known in this country. In response to this interest easily understood and reliable information on gardening has been published by the U. S. Department of Agriculture, U. S. Bureau of Education, State Agricultural Experiment Stations, Agricultural Colleges, and other state institutions in every state. These publications

are available for any school and furnish detailed information applying to any particular locality.

A job for boys and girls. — During the garden season of 1918, about 1,500,000 boys and girls made gardens, and the value of the products from these gardens was estimated at \$15,000,000. Before the War thousands of boys and girls in towns and cities made successful vegetable gardens which not only supplied the home, but produced a surplus sufficient, when sold, to bring considerable return to the producer. Similar success attended the efforts of many boys and girls living on farms, enough to indicate that the problem of the farm garden might easily be solved if undertaken by the boys and girls. In most cases a business arrangement could be made, whereby the gardener would receive a sum for the vegetables supplied to the farm home, equivalent to their cost if bought at the village market.

Preserving garden products. — Preserving food produced in the garden by canning and drying saves much that would otherwise be wasted and, at the same time, provides a winter supply for the home. The great value of this work was demonstrated during the War. It is estimated that, in 1918, 1,450,000,000 quart jars of produce were preserved. Conservation of food should go on also in times of peace. Complete directions for canning all kinds of vegetables and fruits will be found in references in the appendix.

Hot beds and cold frames. — In the Northern States the garden season may be much extended by the use of hot beds and cold frames for the production of early vegetables. The average farmer may not feel that he can afford the time necessary for starting vegetables in this way. But if, as has been suggested, the boy or the girl on the farm undertakes to supply the home with vegetables, the use of the hot bed

and cold frame will be profitable as well as interesting. Early vegetables command a high market price, and those not needed at home may readily be sold.

Construction of hot bed and cold frames. — A hot bed consists of a pit, a frame, and a sash or glass cover. The dimensions of the pit and frame will depend upon the size of the sash to be used. The pit should be two feet deep, and the frame on the north side twelve inches from the ground

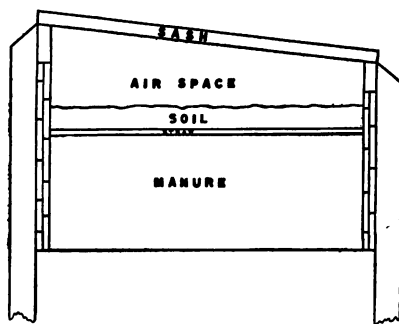


Diagram of section of hot bed showing method of construction.

and on the south side, six inches. The pit should be filled with manure which has begun to decompose. On top of the manure a six-inch layer of good garden soil should be placed. The object of the manure is to produce heat as it ferments or decomposes. After the hot bed has been prepared in this

way it is ready for planting. When planting is done, the bed should be kept moist and covered with glass. On warm days, after the plants are up, the sash should be raised a few inches on one side, but always let down before night. In cold weather the plants should be protected further by covering the sash with a thick layer of straw or other covering so as to retain the heat.

A cold frame is just like the hot bed except for the pit and manure. It is a protection for the plants that are later to be removed to the garden. Plants cannot with safety be set from the hot bed directly into the garden. The change from warm to cool conditions is too sudden. By being transplanted

from the hot bed to the cold frame, the plants are gradually hardened and can then be transferred with perfect safety to the garden.

Truck or market gardening. — The principles of gardening that have been presented are applied on a large scale to truck or market gardening, which is a special kind of farming devoted to the production of vegetables. This kind of gardening is further specialized by limiting the production to a few kinds of vegetables, generally so selected as to cover the entire growing season. Truck farming or market gardening is most profitable near cities where markets are easily accessible.

CHAPTER XIII

FRUIT RAISING ON THE FARM

Fruit as a special crop. — Fruit farming has become a highly specialized industry requiring expert management in the care of orchards and marketing of the products. In most cases where there are regions particularly well adapted to the production of some kind of fruit, we find many farmers giving their entire attention to fruit raising, as the production of oranges and other citrus fruits in California and Florida, apples in Washington, Oregon, Michigan, New York and in portions of several other states.

The importance of one kind of special farming is shown in the value of the product — apples — for a single year. In 1915, the apple crop amounted to more than \$60,000,000. Facilities for keeping fruit in cold storage until ready for the market, its high price on the market and a growing demand seem to indicate a promising field for special fruit farming. But climate, soil, relation to markets, and other factors are so important that much care must be taken in selecting a site for an orchard which will be profitable. Fruit regions are so extensively exploited by advertising, that a prospective investor should make a careful personal investigation and consult with the fruit experts connected with the State Agricultural Experiment Station rather than buy upon the advice of a land promoter.

Place of fruit raising on the farm. — Beside the regions mentioned in the brief reference to fruit farming, there are a

great many farms where enough fruit may be produced to supply all the home needs and often furnish a considerable surplus for sale. Like the farm garden, the farm orchard has been much neglected. There was a time when most farms in the Northern States included apple orchards, but these have been neglected until good farm orchards are now rare. The neglect of orchards may be accounted for in part by the difficulty of keeping fruit trees free from disease and injuries occasioned by insects. Such injuries are much more common now than formerly. But in spite of these difficulties, the advantage of having fresh fruit for home use is, alone, sufficient to encourage the maintenance of a good variety of fruit on every farm where climatic conditions are favorable. Several things are necessary to the successful establishment and maintenance of fruit production on the farm.

Variety and succession. — Since the chief object of the farm orchard is to supply the farm home, attention must be given to securing a variety in kinds of fruit, as well as a succession of ripening periods distributed through several months. In making such a selection, it will be necessary to consult bulletins and circulars from State Agricultural Experiment Stations, and catalogs of reliable dealers.

Succession may be secured first, by planting several kinds of fruit such as apples, pears, peaches, cherries, and small fruit; second, by planting several varieties of each kind, such as fall and winter apples, early and late peaches. But in making such a selection, adaptability to the climate of the locality in which they are to be grown must be considered. Hardiness sufficient to withstand the cold of winter is an important quality.

After the various kinds of fruit stock have been decided upon, they should be purchased from a reliable nursery which

will guarantee them to be as represented. It is of first importance to know that the nursery company is absolutely reliable, one that cannot afford to injure its reputation by selling stock that will not develop as represented.

Establishing an orchard. — The selection of a suitable location for an orchard is of great importance because of its permanent character. In order to give the orchard the right kind of a start, it is also important to know when to plant the trees and how each kind should receive its first pruning.

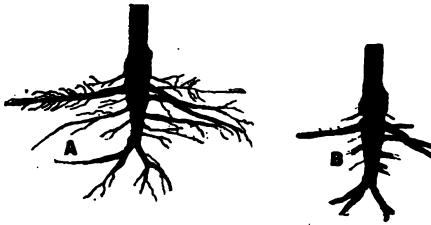


Diagram showing how to prune the roots of a fruit tree before transplanting.

- A. As the plant comes from the nursery.
- B. After being pruned.

Selection of site. —

Convenience, soil, and slope should be taken into consideration when selecting a site. On most farms convenience will be an important matter, for fruit should be near at hand so as to encourage its free use. The soil

should be rich, well prepared, and well drained. Where possible a north slope is preferable to a south slope or level ground.

Time to plant. — Fruit trees, vines and bushes should be set out while in a dormant condition, that is, after the leaves are off in the fall and before the buds swell in the spring. This may either be in the fall or in the early spring. Where winters are severe, spring planting will generally succeed best.

Getting the trees ready to plant. — Trees come from the nursery carefully packed. When unpacked, the roots must not be allowed to dry by exposure to wind or sun. As soon as received they should be set out, or if that is not possible,

they should be "heeled in." Heeling in is done by placing the roots of the trees in a trench with one sloping side, allowing the trunks to rest against the earth of the slope. As soon as the trees are removed from the trench or from the original package, the roots of each tree should be dipped in water to which sufficient clay has been added to make a mush. The moist clay keeps the roots from becoming dry. All injured roots should be cut off.

Setting the trees. — First of all, the soil of the area to be planted should be put in the best possible condition, which

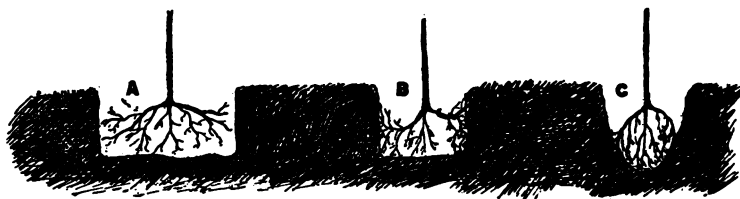


Diagram showing kind of hole to dig for transplanting a tree.

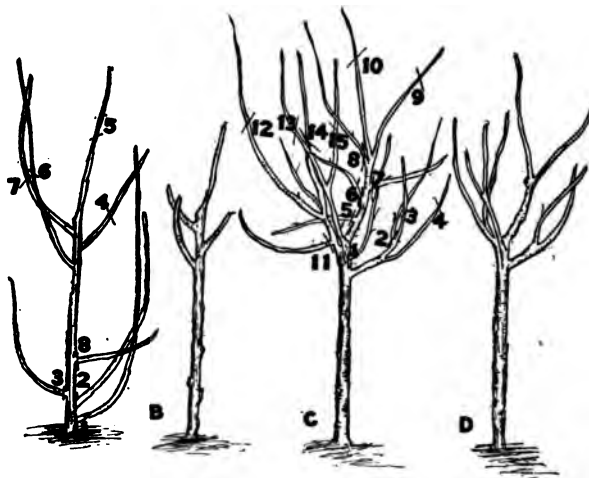
- A. Hole of right size and shape, allowing freedom for good root distribution.
- B. Hole too narrow, roots bent.
- C. Hole carelessly made, roots crowded. (Ohio State Agr. College.)

includes a liberal application of well-rotted manure. The importance of this careful preparation for setting trees is greater than is commonly supposed. The careless method of setting a tree in a hole in the ground and then letting it take care of itself generally leads to disappointment. Fruit trees need, for their best development, the same care in the preparation of the soil that other plants need.

Next, the position of each tree should be indicated by a small stake. In laying out or planning the planting, two things must be kept in mind: first, straight rows facilitate cultivation; second, there should be adequate distance between the trees. Usually the latter point is not sufficiently

considered. A safe rule is to allow enough space for each tree to develop, so that when mature it will neither shade another tree nor be shaded by it.

After the position of each tree has been settled, a hole should be dug, wider than the diameter of the root system of the tree and somewhat deeper. The soil at the bottom



Diagrams showing where a fruit tree should be pruned.

A. A two-year tree as it comes from the nursery.

B. After pruning. C. A year later. D. After pruning.

of the hole should be loose and finely divided. The tree should be placed in the hole with its roots carefully straightened. The dirt should be well packed around the roots so as to bring the soil into close contact with them. If the soil is dry, water should be added. As the other trees are put out in the same way attention should be given to keeping the rows straight.

Pruning. — Sometime before the opening of the spring buds, each tree should be pruned. The object of pruning is to preserve a balance between the roots and branches. Since many of the roots have been destroyed in transplanting, there will not be enough to supply the branches with water and food material if the branches are left as they were in the nursery. Trees properly pruned have a much better growth than those left unpruned.

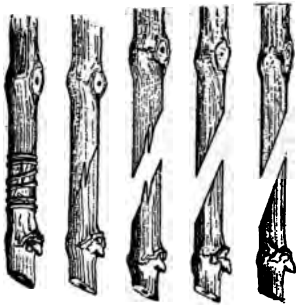
Trees should be cared for. — Giving the fruit trees a good start, as important as it is, will not insure the successful production of fruit. They must also have good care; care of the soil, care in pruning, and care in protection from injuries made by parasitic fungi and insects.

Soil. — The soil should receive the same attention as that given to any other well-cultivated crop. A good mulch should be maintained to conserve moisture. From time to time, manure should be worked into the soil in order to increase its water-holding capacity and to add to the store of plant food. The same results are often obtained by sowing a legume, such as clover, and plowing it under. Orchardists have lately found that sweet clover is valuable for this purpose because of its extreme hardiness and rank growth.

Pruning. — It is difficult to do more in a few words than to present merely the principles of pruning. The details, as applied to different kinds of fruit trees, must be found in special references. The object in pruning a young tree is to control its shape so that sunshine may reach each part. It is desirable that a fruit tree should have a low, spreading shape so that the fruit may easily be gathered. In securing this shape, the branches may be so developed as to let sunshine in to all leaf-bearing parts of the tree. It is also possible, when the tree begins to bear fruit, to control the setting of

the fruit so that it will be borne on the stronger branches near the trunk, thus reducing the possibility of branches being broken by the weight of the fruit.

Insects and diseases.— Each kind of tree has its own difficulties with insects and diseases. For example, the fruit of the apple tree is injured by a disease known as apple rot and by an insect called the codling moth. Apple production is interfered with by many other diseases and insects, but these are mentioned as important examples. Control of insects and diseases is absolutely necessary for successful fruit-raising. In general, spores which may develop into fungi and cause disease are destroyed by means of chemical mixtures known as fungicides, and insects are killed by means



Diagrams showing successive stages in making a graft. (California Agr. Exp. Station.)

of poisons. Both are applied in the form of a solution by means of sprays. Usually the application of a fungicide for control of plant diseases is made in the spring before the buds open, but in some cases it may be made when the tree is in full leaf. In either case the spray is intended to kill the spores of the disease-producing fungus. For example, if peach trees are sprayed before the buds

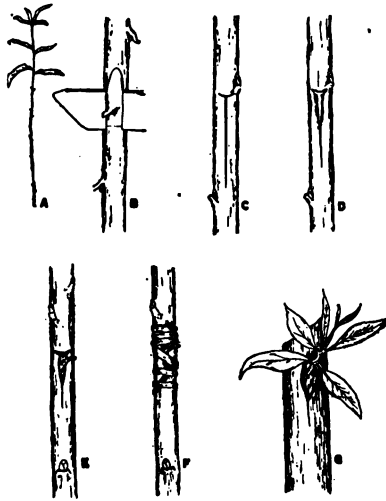
swell, with the Bordeaux mixture, the spores of the fungus which causes leaf curl will be destroyed, and this injury controlled. The control of insects by the application of poisons depends upon the habits of the insects. For example, it is the habit of the plum curculio to make a hole in the plum and deposit eggs. She may be injured before egg laying is accomplished if a poison, such as arsenate of lead, is

applied after the bloom has fallen when the young plums are just beginning to form. .

Plant diseases and insects not only interfere with fruit production, but, to a certain extent, with every other kind of plant production. Some of the main general facts relating to each are presented in Chapters XV and XVII. Bulletins and circulars are furnished by the U. S. Department of Agriculture and by State Agricultural Experiment Stations, which give detailed instructions for the control of plant diseases and insects that are associated with each kind of fruit. These should be studied in connection with this chapter. In the appendix will be found a spraying program for orchards and fruit gardens.

Improving the orchard by grafting and budding.

— After fruit trees have become established, it may be desirable to extend the varieties. This may be done without further planting, by grafting and budding other varieties on to trees already developed. In this way one tree may be made to produce several kinds of fruit.



Diagrams showing the process of budding

- A. Twig from which buds are cut.
- B. Cutting bud from twig.
- C. Making T-shaped cut for insertion of bud.
- D. Bark raised for insertion of bud.
- E. Bud inserted.
- F. Bud tied on.
- G. Bud developing into twig.
(Missouri Agr. Exp. Station.)

The principles of grafting and budding are simple. They consist essentially in bringing the freshly-cut surface of the branch of the tree (called stock) on which the graft or bud is to be set into contact with the cut surface of the twig to be grafted (called cion), or into contact with the bud to be set. The cut surfaces must be brought together in such a way as to make a portion of the cambium, or growing layer of the stock, touch the cambium of the cion or the bud. In the case of grafts, they are held in place by grafting wax pressed around the union; in the case of buds, by means of a coarse string or bit of raffia.

Some trees, such as the peach, are easily budded, while others, such as the apple, are grafted more successfully. Grafting and budding take some time and attention, but the results are interesting and often worth while. Boys and girls can do the work quite as successfully as adults.

CHAPTER XIV

PLANT IMPROVEMENT

Meaning of plant improvement. — Plant improvement refers to the practice of securing high-yielding plants and keeping them at a high level of production. Agricultural plants vary greatly in their capacity for production. Attention has been called to the importance of selecting plants which are best adapted to the soil and climate of the particular region where they are to be grown. But this is not the only selection necessary to secure a high yield. Among plants of the same kind there are differences that must be considered in order that maximum production may be reached. For example, the yield of a single variety of corn, such as Reid's yellow dent, will vary in the same locality, although the fertility of the soil, preparation of the seed bed, cultivation, and other factors influencing the growth of the plant are similar. Other things being equal, the greatest yield will occur when the most careful attention is paid to the selection of seed. It requires but little more labor and expense to produce a crop from high-yielding plants than is necessary to produce one from low-yielding plants.

How high-yielding and otherwise desirable plants are secured. — Considering only those qualities possessed by plants themselves, and not those resulting from fertility of the soil or from other agencies influencing plant growth, highly productive plants, or plants having exceptional qualities, are secured in four ways: by introducing plants from

other countries; by propagating new plants as they are noticed among other plants of the farm; by crossing plants, thereby combining the good qualities of two or more plants into one; by selection. It will be of interest to notice each of these separately.

Introduction of foreign plants. — Most of our agricultural plants have been brought to the United States from other lands. Our country was settled by people from different parts of the world. When they came here, they brought with them seeds and plants from their old homes. Some of the plants were well adapted to their new environment and flourished even better than in the old. The successful plants became well established, while the production of others not so well suited has been abandoned. In some such way as this, many of our most important farm plants were developed and extended to different parts of the country adapted to their growth. At the same time, largely through unconscious selection, they were improved and became in many instances better than the original parent plants.

Many farmers, who were able, explored other lands and brought back to this country plants that held promise of being useful here. For example, the Mediterranean wheat was introduced, in 1819, from the islands of the Mediterranean Sea.

As early as 1839 the United States Department of Agriculture became interested in making similar explorations. Between 1839 and 1880, sorghum, Kafir corn, varieties of sugar cane, and other plants were introduced. The results of these early explorations seemed so valuable that, in 1898, substantial appropriations began to be made to carry on this work. In 1901, when the Bureau of Plant Industry was formed, Plant Introduction was included as a division of

this Bureau. The purpose of this division was to explore the world systematically and to bring back to this country plants that might be valuable to our agricultural production.

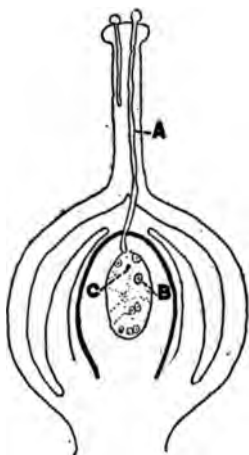
As now organized, this division consists of two branches: that of exploration, which places several men in the field to travel over the world in search of useful plants; and that of propagation, which tries out the plants sent here by the explorers to determine their agricultural value. If they prove valuable when fully tested, they are distributed to farmers for actual introduction.

Many plants, some more productive than similar kinds already grown here, and others, new kinds of great agricultural value, have been found and introduced. Among the former, for example, are the durum wheats introduced in 1898 from Russia. These wheats are well adapted to the semi-arid regions east of the Rocky Mountains, extending from Texas to North Dakota, which are too dry for ordinary wheat. Besides, the durum wheats are especially valuable for the manufacture of macaroni. The production of these wheats, in 1919, amounted to about \$50,000,000. Among other plants that have been successfully introduced are Japanese rice, date palm, Swedish oats, Turkestan alfalfa, and Egyptian cotton.

The work of the government in plant introduction is deserving of more than this brief account. Further information may be found by consulting recent yearbooks of the United States Department of Agriculture.

Sudden appearance of new plants among the old. — Occasionally, in nature, a plant will appear which is noticeably different from its companions. The same is true of cultivated plants. When a plant is found that is clearly different from others of its kind, it may be better than the others.

It should be watched closely and the seed saved in order to propagate more like it, so that it may be tested. It may prove to be of no especial importance, or it may have some very desirable qualities not possessed by others of its kind.



Pistil of flower showing single ovule at time of pollination.

A. Pollen tube extending from pollen grain on the stigma to embryo sac which contains the egg nucleus.

B. Egg nucleus.

C. Fertilizing body which has come from the pollen grain by means of the pollen tube — C and B unite to form the fertilized egg. For details see figure on page 151.

A number of important cultivated plants seem to have originated in this way. The Fultz wheat is an example. In Pennsylvania in the summer of 1862, Abraham Fultz when going through his field of Lancaster wheat, which is a bearded variety, happened to notice a plant whose heads were not bearded. This was so unusual that he kept close watch over the plant during the remainder of the growing season, and at harvest time he saved the heads of it. He removed the grains, planted them in a plot to themselves, and later similar beardless plants appeared. Again he saved the seed and planted a still larger plot. This operation was repeated until he produced enough seed to plant his entire farm. He afterwards turned over to the U. S. Department of Agriculture a considerable amount of seed for distribution. Since then the Fultz wheat has been

considered one of the best varieties adapted to the eastern part of the Corn Belt.

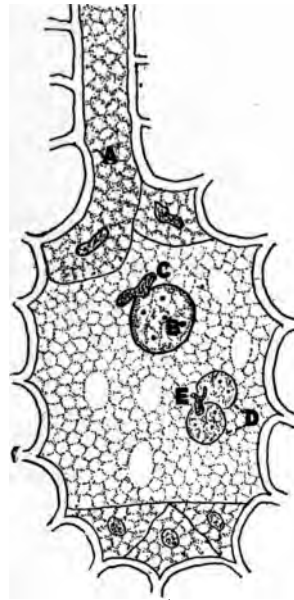
The Clawson wheat, a variety with white grains, first

appeared in a field of Fultz, in 1865. The Rudy originated in a large field of wheat near Troy, Ohio, in 1871. The Concord grape, nectarine, navel orange, and many other valuable kinds of fruit probably originated in a similar way.

Improving plants by crossing.—

In order to understand crossing or hybridizing, it will be necessary to review briefly the way in which plants produce seed. For this review we shall begin with the flower. The essential parts of the flower are the stamens and pistil. Each stamen has at its end a small sack containing minute structures called pollen grains. The pistil is enlarged at its lower end, forming the ovary in which one or more small bodies are located from which seed are developed. But these bodies are unable to develop into seed without the aid of pollen. A pollen grain which may happen to lodge on the upper end of the pistil, called stigma, sends an outgrowth like a slender thread, called pollen tube, down the neck of the pistil into the ovary. A

small part of the pollen substance passes down this thread, or pollen tube, and when it reaches the ovary unites with the seed-producing body inside. This union is called fertili-



Embryo sac of lily showing fertilization taking place.

A. Pollen tube.

B. Egg.

C. Fertilizing element (nucleus) from pollen tube uniting with B. From the cell produced by this union the germ of the seed develops.

zation, and after it occurs the seed-producing body may develop into a seed.

The significance of fertilization lies in the fact that each of the two bodies which unite in this process carries with it characters of the parent producing it. If the fertilizing bodies are from the same plant, the seed which is formed by the union will produce a plant like the parent plant. But if these bodies come from different plants, such as different varieties of cowpeas, the seed formed from this union will produce a plant in some respects unlike either parent, but having some characters of each. In such instances the new plant will combine the characters of both parents, although some of the characters of each will dominate, or make obscure similar characters of the other.

By observing the principles of heredity, plant breeders are able to combine the desirable characters of different parents. Such a procedure is known as crossing or hybridizing. For example, a smooth, bearded variety of wheat may be crossed with a rough, beardless variety so as to produce a smooth, beardless variety. This will be a combination of characters that did not exist before, and in this case, probably a more desirable combination than that possessed by either of the parents. An almost endless variety of useful plants has been developed in this way. *

Some of the results of crossing are so wonderful as to attract wide attention. Perhaps the best known plant breeder who made use of this method is Luther Burbank. Among the plants that he has been able to develop are varieties of plums, prunes, potatoes, chestnuts, walnuts, and many flowers, such as the Shasta daisy.

Scarcely less wonderful is the work of Professor N. E. Hansen of the South Dakota Agricultural College. He has

developed a plum which will withstand the severe cold as far north as Winnepeg, a kind of alfalfa that will grow in a cold climate, and many other interesting and valuable plants.

Reference should be made to the results achieved by the U. S. Bureau of Plant Industry, in which G. W. Oliver has had a prominent part, as an expert propagator. Among



A good type of ear of corn for field selection. It is growing on a vigorous plant. The ear is at the right height and has a desirable angle. (Indiana Agr. Exp. Station.)

these results are a rust-proof asparagus, improved varieties of lettuce, alfalfa, cowpeas, and of many other plants.

Improving plants by means of selection. — The average farmer will not have the time or experience to use the methods just described to secure better plants, except the method of looking out for new plants that may appear in his fields. He should know about them, however, so that he may secure the new plants introduced by the Bureau of Plant Industry or developed by expert plant breeders, if it seems to his advantage.

The method of improving plants by selection is one that every farmer should employ on his own farm. Selection is based upon the fact that plant characters are handed down, or inherited, from one generation to another. The application of selection lies in the use of seed from desirable plants. There is no way of telling by the appearance of the seed whether it will produce low- or high-yielding plants. For example, several ears of corn may be nearly perfect in size, shape, and in other desirable qualities. But there is no means of knowing whether or not these desirable qualities will appear in the crop produced from these ears, unless each ear is tested separately. In fact, there is apt to be much difference in their ability to produce.

A description of an actual trial of this kind will illustrate this point. Thirty ears of corn, uniformly good in outward appearance, were used. Enough seed from each ear was planted to produce a row of one hundred hills. When the rows were harvested separately and the corn weighed, the results showed a variation in yield, per row, from thirty to one hundred and twenty pounds. Only five rows gave a yield of over seventy-five pounds each. In other words, the trial showed only five ears of high-yielding corn, the rest were low.

There are several steps to be observed in securing better plants by selection. These may be made clear by using corn as an illustration.

Initial selection. — Initial selection is made in the field during the latter part of the growing season. Those plants showing vigorous development, having broad, dark green leaves, well-formed ears neither too upright nor too pendant, a convenient height, well-developed brace roots to prevent lodging, an absence of suckers, and other desirable characters,

should be marked in such a way as to make them easily noticed when the corn is husked. When mature, the ears from all the selected plants are kept separate and cared for according to suggestions made in Chapter VIII.

Final selection. — Final selection may be put into practice shortly before planting time in the spring. First, each ear saved should be examined carefully to discover such characters as injuries from disease, poor shape of ear or kernels, poorly



Harvesting at end of an ear-to-row test. Shows method of determining which seed ears have produced the greatest yield. (U.S. Dept. of Agriculture.)

filled butt or tip, and any other features undesirable in an ear of corn. Defective ears should be thrown out. Next, a germinating test should be made of the remainder and the ones showing poor germination should be thrown out. From the remaining ears, twenty to fifty of the best should be selected for the ear-to-row trial, the others may be used for planting the regular crop.

Ear-to-row trial. — An ear-to-row test, as the name indicates, means the planting of one row from each ear, usually a row of one hundred hills. A corner of the field which is to

be planted in corn is laid off in rows for the test plot. Each row is numbered to correspond to the number of the ear that is to furnish seed for that row. About 350 kernels are taken for planting from each ear and placed in a bag marked with the number of the ear. The remainder is left on the cob and put away for possible future use. After this preparation, each row is planted according to number, row number one from ear number one, etc. The plot should receive the same care and cultivation as the rest of the field. During the growing season the various rows in the test plot should be examined from time to time, and those plants showing disease or other faults should be detasseled. When fully ripe, the corn from each row is harvested separately and weighed. The corn from rows having the highest yield is saved for further trial. The rest may be used for any other purpose. Ten or twenty of the best ears from the highest-yielding rows should be saved for the second-year test.

Multiplying plot and second-year test. — For the ear-to-row test of the second year, select for use the best ears produced from the high-yielding rows of the first year's test and the kernels left on the ears saved out of the original planting, which correspond to these high-yielding rows.

For the multiplying plot, select the good ears remaining in the high-yielding rows and plant in a separate plot to furnish seed for the farm. Since all the seed used in it is from high-yielding rows of the original test plot, it is reasonable to expect the multiplying plot to furnish high-producing seed corn. By this means of selection, high-yielding seed may be developed in time for general planting the third year, but it is desirable to continue the ear-to-row trial a few more years, until several high-yielding strains have been fully established.

The yield may be increased further by crossing. The result of the ear-to-row tests is really the separation of high-yielding strains from a mixture of low, medium, and high-yielding plants. Experiments made under the direction of the Connecticut Agricultural Experiment Station have shown that an increase of as much as ten bushels per acre may be secured by using seed produced by the crossing of two high-yielding strains, as compared with the yield of either parent alone. In farm practice, all that is necessary is to plant alternate rows of two high-yielding strains that have been developed by the ear-to-row test. The seed thus produced is used for the next year's planting. A separate plot of each pure strain must be maintained in order to keep up a supply of seed for future crossing.

A recent modification of this plan has even greater promise. It is essentially a double cross. Two pairs of high-yielding strains are crossed. The plants resulting from this cross are recrossed. Seed from these plants produce a strain of corn of higher yield than the original stock. After the final strain has been established it may be maintained by ordinary careful methods of selection.

While the method of improvement just outlined may seem somewhat difficult, it really requires but little time and effort.

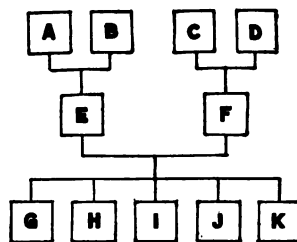


Diagram showing double cross of corn to secure increase in yield.

A, B, and C, D are ears of high-yielding strains selected by ear-to-row method.

A and B are crossed, producing E.

C and D are crossed, producing F.

E and F are then crossed, producing G, H, I, J, K, etc. These ears furnish seed for general planting, producing maximum yield.

It should result in the development of seed capable of producing a much higher average yield than that obtained by the usual methods of corn selection. An increase of at least ten bushels per acre is not too much to expect. There is probably no other means of increasing production with as little additional labor and expense as this.

Four-hill-unit method of improving potatoes by selection. The same principles of selection are used in the tuber-unit method of improving potatoes. The essential features are as follows:

The initial selection is made in the field of good tubers from high-yielding hills. The tubers selected should each weigh about five ounces, should be entirely free from evidences of disease, and should conform to type.

Each tuber is cut into quarters and planted in four hills, the four hills forming one unit. Other units are planted in the same way, but, to avoid confusion, a greater space is left between units than between the hills of a single unit. For the test plot of the first season at least one hundred units should be started. A system of numbering should be followed in order that an accurate record of each unit may be kept. A careful observation of the plants should be made from time to time, and a record kept of such qualities as vigor, growth, freedom from disease, and of other points that may be of value in determining the best plants. All weak and undesirable units should be eliminated entirely as soon as discovered. This may be done either by checking off their records and paying no more attention to them or by removing the plants entirely.

Finally, the tubers of each unit are harvested separately and put into a separate bag. Only those tubers of the highest yielding units should be preserved. These should be further

examined for quality, size, and trueness to type, and only those units that come up to a good standard should be retained. Ten of the best tubers of the selected units are to be used for the next year's test.

The second year each ten tubers saved from the desirable units of the first year are quartered and planted to a unit of forty hills. The same procedure is followed as in the first season. The best tubers of the best forty-hill units should be saved for planting the third season. By this time, high-yielding strains of desirable tubers will be established, with enough tubers to plant a large plot. But forty or more exceptionally good tubers from the best forty-hill units should be saved to continue the best pure lines or units. At the end of the third year enough seed of high-yielding strains will be secured for most of the planting needed for the farm. Besides, the extra tubers may be sold for seed at high prices.

The investment of time and labor in developing a superior strain of potatoes by this method is small compared with the results that may be attained. For example, one farmer was able in a few years to establish a strain which gave him a yield averaging 282 bushels per acre for nine years, while his neighbors secured an average yield of approximately only 150 bushels. The difference of 132 bushels per acre would seem to be a good return for the time and trouble needed to establish a high-yielding strain of potatoes.

Improving other plants by selection.—This same method of getting better plants by selection may be applied to other crops such as wheat, oats, barley, etc. In this case smaller plots should be used, otherwise the procedure is essentially the same as for corn.

In several states plant-improvement associations have been

formed for coöperative work in developing high-yielding strains of different crops, by selection. The results obtained in Wisconsin by such associations illustrate what can be done for plant improvement in this way. These associations, with the assistance of the Wisconsin Agricultural Experiment Station, have developed high-yielding strains of dent and flint corn, barley, wheat, oats and other farm plants. Similar results have been obtained through coöperative work among farmers of Indiana and the State Agricultural Experiment Station.

It may not be out of place here to make a suggestion to the boys living in a corn- or potato-growing region. In a few years any boy could develop corn or potato tubers for seed which would bring high prices on the market. If such a scheme were begun when he was in the eighth grade, his product would be ready for sale by his second year in high school and would continue, becoming larger each year. In this way, he could provide means to continue his education in an agricultural college or elsewhere. In addition he would not only secure a return for himself, but would be doing a real service to the farmers of his community.

CHAPTER XV

PLANT DISEASES

Interference with plant growth.—The influence of a fertile, carefully prepared and cultivated soil and of high-yielding plants in crop production has been considered somewhat in detail. But even when these important and necessary provisions for producing crops are made, production will not necessarily come up to its possibilities, owing to the interference of harmful agencies that are always operating to a certain extent.

Such agencies are plant diseases, weeds and insects. While the losses occasioned by them cannot be prevented entirely, they may be controlled in some measure. Such control must be directed by an understanding of the nature of the injuries and of the agent concerned. In order to present a basis for such an understanding, a chapter will be devoted to the discussion of some of the most important facts relating to each of these agencies.

What is meant by plant diseases.—Our association with plants is largely with those that bear flowers and produce seeds. But there are many thousand kinds of other plants, sometimes referred to as lower plants, which we do not easily notice. Of the lower plants, those of one group, known as fungi, are distinguished by the absence of chlorophyll, or leaf green, and consequently are unable to make carbohydrates, such as sugar and starch. For this reason the

fungi must get such substances already made. Some of them — molds, mushrooms, puff balls, and species of bacteria — rely upon dead material, such as the remains of other plants, for their supply of food material. Others — rusts, smuts, mildew, blights, and other kinds of bacteria — satisfy their needs by attaching themselves to other living plants. These latter are called parasitic fungi, and the plant that gives them a living is called the host. Since a parasitic fungus deprives its host of starch and other food material, and makes harmful poisons, it weakens and otherwise injures the host, thus producing conditions known as disease.

In order to understand how these injuries are made and how disease spreads from one plant to another, it will be necessary to consider how fungi grow.

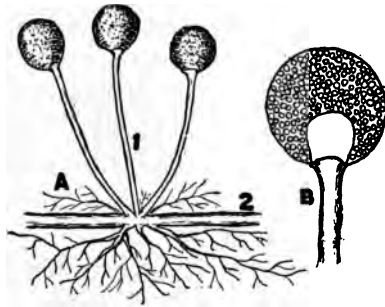
How fungi grow. — There are two essential parts of most fungi: One, the food-getting part, is composed of a net work of fine threads or tubes, called the mycelium, which usually penetrates the food substance on which the fungus grows. The other, the reproductive part, is composed also of fine threads which bear small bodies called spores. The spores, being light, are easily blown about by the wind or being sticky are carried by insects, animals, or water to different places, where, if conditions are favorable, they develop into plants like the ones that produced them. Sometimes the spores are borne free at the ends of the spore-bearing threads, and thus are easily transferred from the parent fungus to other places, ready to start new fungus growths. Sometimes they are enclosed in cases. In this instance, the walls of the case break when the spores are ripe, thus releasing them for distribution.

Bacteria have already been described in connection with the soil, but should be considered here with fungi, since they

behave in many respects like fungi and are regarded as such by many botanists. Bacteria grow to a certain size and then divide. This growth and division continues until a great number of individuals is formed. Under certain conditions, such as lack of moisture or food, they cease to develop, but undergo changes which enable them to keep alive. When in such a condition they may be carried about by the wind or other means until conditions favorable for renewed activity are met. Some bacteria get their food from other living plants, thus becoming parasites, and cause disease. An example of this type is the organism causing pear blight.

In order to recognize the way in which fungi grow, it might be profitable to study the common black mold as it is seen on

bread left in damp places. The black mold does not ordinarily injure plants by causing disease, but a study of its manner of producing spores will aid in the understanding of parasitic fungi which are harder to study. At first the black mold consists of a net work of fine threads spreading over and extending into the bread. Later very small, dark specks may be seen on the upper surface of the mass of threads. On close inspection it will be seen that each black speck is a tiny ball borne upon the end of an upright thread. When examined with a lens, the ball will be seen to be filled with



Diagrams showing essential parts of the black mold.

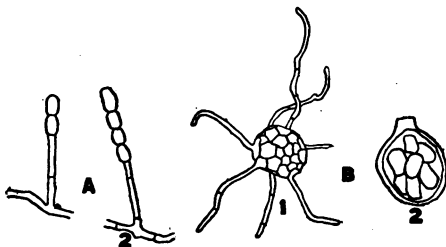
A. Showing how spore cases are related to other parts of the mold.

B. Single spore case showing spores inside.

still smaller bodies. These small bodies are spores. If some of these spores are scattered over the surface of a piece of damp bread, each will start to grow and a new growth of mold will soon appear.

Powdery mildews, which frequently are found on the leaves of the lilac, rose, and other plants, are parasitic fungi. Small projections, called haustoria, extend from the threads and secure

food from the living cells of the leaf. The threads are on the surface of the leaf, giving it the appearance of being covered with fine down or cobweb. Among these threads on the surface of the leaf, spores are to be found, some uncovered and others enclosed in spore cases. Some of



Mildew

A. Chains of summer spores; 1 and 2 different stages of development.

B. (1) Spore case containing sacs of winter spores.

(2) A sac showing winter spores.

(Washington Agricultural Experiment Station.)

these spores are carried, when ripe, by the wind or by other means to uninfected leaves where they develop into new fungi.

Means of control of plant diseases. — There are several general methods of control of plant diseases.

One method is based upon the destruction of spores which may infect healthy plants. This is accomplished when seed is disinfected by means of a chemical compound such as formaldehyde or corrosive sublimate, or the spores killed by means of heat. For example, seed potatoes may be treated with formaldehyde before planting. Oats may be treated

with formaldehyde and wheat with hot water to kill the smut spores. A different mode of application is illustrated in the control of onion smut. In this case a formaldehyde drip attached to the seed drill kills the smut spores in the soil immediately surrounding the seed and thus protects the young onion plant from infection.

A second method is that of spraying the surface of the leaves, fruits and branches of the host plants with a fungicidal compound such as Bordeaux Mixture or lime sulfur. By this means the spray compound forms a protective layer and poisons any spores which may alight on the host as soon as these spores begin to germinate. For example, apples are sprayed to control scab and other diseases, and potatoes are sprayed in the Northeastern States to control late blight.

A third method is that of selecting disease-free seed. This is practiced to control corn root-rot, potato diseases, and sweet potato diseases. In some cases, as in that of corn root-rot, seed testing is an important item, while in other cases it is necessary to secure seed from fields or from regions where certain diseases are not present.

A fourth method is that of varying planting dates so that crops will escape certain diseases. For example, the earlier spring wheat is planted the less will be the loss from wheat rust. Another example is the growing of seed beans during the hot weather of the fall in Louisiana when the temperature is so high that it controls the anthracnose disease.

A fifth method is that of eradicating other plants, usually worthless, which may harbor plant diseases destructive to crops. For example, the common barberry serves as host of wheat rust and is being generally destroyed for that reason; likewise the red cedar is the host of apple rust. Certain

weeds are hosts of fungi that may infect and cause diseases of cultivated plants.

A sixth method is that of sanitation. It is usually accomplished by rotation of crops so that one crop is not exposed to infection from the residue of the preceding crop. Rotation of crops is important in controlling corn smut, tomato wilt, wheat scab, and the root-knot disease which is very severe in the South.

A seventh method of disease control is the use of resistant or disease-escaping varieties of plants. The method is based upon the fact that some plants are more hardy and less liable to infection than are others. One object of plant breeding is to produce plants with a high resistance to disease, and considerable progress has been made in this direction. The use of resistant varieties is especially important where it is impossible to control diseases by the other methods. For example, asparagus rust seemed impossible of control until resistant varieties were developed. Yellows-resistant cabbage is another example.

Importance of controlling plant diseases. — The total loss of cultivated plants in the United States, due to plant diseases, has been estimated at \$600,000,000 annually. When we remember that there is no kind of plant that may not be infected by some disease, these figures are not surprising. In the control of plant diseases, as in the control of human diseases, preventive measures are the most important.

The common diseases should be known so well as to be recognized easily, so that measures for control may be taken in time to prevent much damage. The diseases of the cultivated crops of each state have been studied by members of the staff of the State Agricultural Experiment Station and of the U. S. Department of Agriculture. The results of these

studies are usually published in bulletins which furnish detailed information in regard to particular diseases, that cannot be given in a text like this. These references, as well as those indicated in the appendix, should be used for further study and information. Such a study will be worth much more if the diseases of the plants which are common on the home farm are used as a basis, and through such study a means of control put into operation.

Common parasitic fungi. — Detailed study of most parasitic fungi is difficult and requires special training. It is possible, however, to recognize many common plant diseases by noticing the effects produced on host plants. These effects may be regarded as symptoms of disease. They are classified according to the general appearance of the injury, as follows: rot, blight, wilt, mildew, leaf-spot, scab, canker, smut, and rust.

Rot. — The name itself suggests the nature of the injury caused by this class of diseases. The fleshy parts of a plant are most often affected, although the injury is found on other parts of some plants. Examples:

Bitter rot of the apple. — It appears, at first, on the fruit as small, round, rotten spots. Later the spot becomes dry and dark colored. The spot increases in diameter, gradually involving the entire fruit. The surface becomes wrinkled, and, toward the center of the rotten area, small elevations

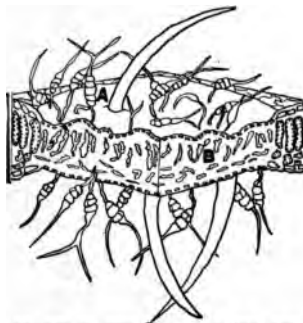


Diagram of section of a leaf spot of early blight of potato.

A. Spores.

B. Withered remains of cells of leaf. Note how much this portion of the leaf has shrunk.

(Adapted from Rands: Wisconsin Agricultural Experiment Station.)

(pustules) bearing spores appear. This disease is most noticeable about the time the fruit begins to ripen.

Brown rot. — This is a common injury of the peach, plum and cherry. The fungus attacks the fruit as it approaches maturity, first appearing as a round, dark spot and gradually extending over the entire fruit. As decay advances small bunches of brown threads appear, at first near the center of the original spot, and rapidly extend until the whole fruit is covered. If the infected fruit remains on the tree it shrivels up into what is known as "mummy fruit," and may hang there during the winter. On examination of "mummy fruits" some will be found bearing small mushroom-like bodies. These bodies bear spores which may start a new infection.

Black rot. — This rot attacks grapes. It begins as dark purple spots which gradually involve the whole grape. Later the grape shrivels up and turns black.

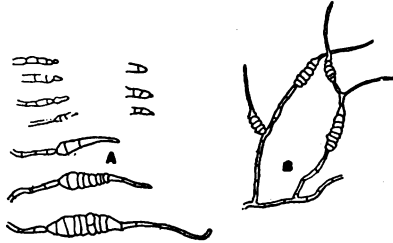
Bacterial soft rot. — This is a very foul smelling, slimy, soft rot of the tissues of fleshy vegetables such as cabbage head, carrots, turnips, onions, and potatoes in storage. This rot may be checked by keeping the temperature low, by thoroughly drying all the surfaces before the vegetables are put in storage, if necessary, by exposing them to the sun, and by avoiding bruises and wounds as much as possible.

Dry rot of potatoes. — This is the common rot of potatoes under ordinary cellar storage conditions. It is caused by a fungus which grows well at rather low temperatures but which as a rule can not invade the potato except through the wounds. Potatoes should be handled as carefully as apples if rot is to be avoided.

Blue mold rot. — This is the common mushy, soft rot of apples in storage, and as a rule follows wounds or the diseased spots caused by other parasites.

Blight. — This name is applied to diseases which result in a rather sudden death of the host plant or portions of it, such as leaves or branches. Examples:

Fire blight. — This is a disease caused by bacteria. Although bacteria are not true fungi, they are like the fungi in their food requirements, and some cause injuries similar to those made by parasitic fungi. Fire blight attacks the leaves and twigs of apple and pear trees, causing them to shrivel and blacken as if burned. The leaves of the diseased twigs do not fall as do the leaves of healthy twigs. This fact makes it possible to recognize the blight in winter. In the spring the diseased twigs may be recognized by their dead, black leaves.



Spores of early blight of potato.

A. Various stages of development of spores.

B. Mature spores. (Wisconsin Agricultural Experiment Station.)

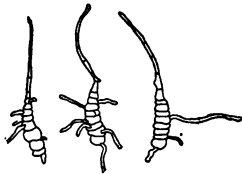
Bean bacterial blight. — This is a destructive disease of the bean crop throughout the country. It produces large, brown, parchment-like spots on the leaves, small, sunken, water-soaked spots on the pods, and in addition may kill the plant outright by forming a canker on the stem or by clogging the water tubes.

Late blight of potato. — This is the most destructive disease of the potato crop in the Northeastern States. It is characterized by large, dark brown spots on the leaves. These spots enlarge rapidly involving the entire leaf surface. The tuber is also affected, a dry, brown rot appearing in its outer tissues. Late blight is caused by a fungus which spreads rapidly during

the cool, wet weather which frequently prevails in the Northern States, and sweeps across whole fields in a very short time. Not only does it destroy the foliage and thus reduce the yield of tubers, but also causes a dry rot of the outer tissues of the tubers and exposes them to infection by the dry rot of potatoes mentioned above.

Wilt. — The name indicates the character of the injury. The roots or parts of the stem are injured, thus cutting off

the water supply from the leaves and upper parts of the plant, causing them to wilt. Examples:



Germinating spores of early blight of potato.
(Wisconsin Agricultural Experiment Station.)

Cabbage yellows. — This is the most destructive disease of cabbage in the United States. It is caused by a soil fungus which invades the roots and grows up through the water-conducting system of the plant so as to make the vegetables worthless

from the commercial point of view. Sometimes the plants wilt, but ordinarily the most striking symptom is the yellow discoloration and dropping off of the lower leaves, and the failure of the cabbage to develop a marketable head. Yellows-resistant varieties of cabbage have been developed.

Other examples of typical wilt diseases are potato wilt, tomato wilt, and watermelon wilt caused by soil fungi, and the bacterial wilt of cucumbers and muskmelons which is carried from plant to plant by insects.

Mildew. — There are two entirely different types of mildew among plant diseases. One of these types, called powdery mildew, in which the mycelium or vegetative part of the fungus lies on the surface of the host, has been described in a previous paragraph. It is illustrated by such diseases

as the common powdery mildew of the lilacs, the powdery mildew of roses, and the mildews on gooseberry and cherry foliage.

The other type of mildew is called downy mildew. This type of disease is caused by a fungus which grows within the tissues of the host rather than on the surface. It is illustrated by such diseases as the downy mildew of the lettuce which is very common in greenhouses, the downy mildew of onions, and the downy mildew of grapes.

Spot diseases. — Many diseases are characterized by the formation of definite disease spots on the foliage, fruit, or other parts of the host plant. In cases of severe attack these spots may become so numerous as to lead to the death of the host, while in other cases the effect is not so severe.

The leaf-spot diseases of beet, cherry, strawberry and tomato are good examples of this class of diseases as they occur on foliage. Other examples:

Apple scab. — In this disease the spots are produced on the foliage and fruit making a distinctly scab-like appearance. On the fruit the scab first appears as an olive green, circular spot. This spot enlarges very slowly and causes damage because it disfigures the fruit and exposes it to rot-producing fungi.

Peach scab. — This disease is characterized by small circular spots on the young twigs, and by very small freckle-like spots on the fruit which occasionally merge to form rough blotches and possibly a cracking of the surface of the fruit.

Practically all the scab diseases may be controlled by spraying.

Galls. — Some plant diseases result in the formation of large overgrowths of the host tissue. Club-root of the cabbage, crown gall of raspberries, fruit trees and other plants, and the black wart of the potato are good examples.

Canker. — Some tree diseases produce large dead areas in the bark which enlarge more rapidly than the tree can produce callus, and thus eventually girdle the trunk or limb to cause the death of the tree. Such cankers are produced by the fire-blight diseases of apple, by the Illinois apple-tree canker, by the chestnut-blight disease, and by the citrus-canker disease.

Apple canker. — Several diseases cause cankers on apple trees. Among the most destructive of these is the Illinois canker, the black-rot disease, and fire blight. The apple-blotch disease also produces destructive cankers on young twigs. Not only are these cankers destructive in themselves, but they afford means for the parasites to live over winter.

Smut. — Smut diseases are so named because of the characteristic masses of black powdery spores which are produced on the host, often in the place of the normal grain which would otherwise have been produced. These diseases are most common on the cereal crops such as corn, wheat, oats and barley, although there is a destructive smut of onions.

Rusts. — The rust diseases are characterized by the yellowish or reddish appearance which the small powdery cushions of spores give to the surface of the host plant. The most destructive rusts are probably those which affect our cereal crops such as the black stem rust of wheat or other cereals. The leaf rust, also found on cereals, is caused by an entirely different fungus from that producing the black stem rust. Other examples of destructive rusts are the rusts of the apple, of the bean, of the raspberry, and of asparagus.

The fungi which cause the rusts can live only as parasites and do not grow when removed from their special host. This is not true of many of the other diseases that have been mentioned.

CHAPTER XVI

WEEDS

What weeds are. — Nearly everyone knows that weeds are plants which are not wanted. Someone has defined a weed as a “plant out of place.” Plants that are sometimes useful may be regarded as weeds if they interfere with other plants that are desired. Sweet clover is a good example of such plants. Under certain circumstances it may be a valuable crop for green manure, but at other times it may become a pest.

Losses due to weeds. — “The direct loss in crops, the damage to machinery and stock, and the decrease in value of land due to weeds, amount, without question, to tens of millions of dollars each year — a loss sustained almost wholly by the farmers of the nations.”

How weeds interfere with crop production. — An ideal for crop production would be to have all the necessary water, plant food, and sunshine available for the plants being produced. The presence of other plants that make use of these things tends to interfere with production by depriving the cultivated plants of the amount needed for their best development. For example, the amount of water taken up by a vigorous weed amounts to as much or more than is needed by a cultivated plant. Some recent experiments, designed to determine accurately the effect of weeds on the production of corn, showed a loss in the yield of as much as 38 bushels per acre. This merely confirms what can be observed in nearly every farming community.

Besides depriving cultivated plants of water and other requirements for their growth, the presence of weeds in hay and forage crops reduces their value for feeding purposes.

Weeds are also responsible for the continuance of many



Effect of weeds on crop production. Ground plowed, seed bed prepared, weeds allowed to grow. Yield, 8 bushels. (Illinois Agricultural Experiment Station.)

plant diseases, such as rusts, by acting as host for the fungus until the cultivated plants appear. Weeds bear a similar relation to insects.

Why weeds are difficult to control. — Weeds are extremely successful in competing with other plants because of several characteristics. They are able to withstand adverse con-

ditions such as extreme dryness or cold. In the most unfavorable situations, such as dry roadsides, they are able to grow and produce seed. They are able to produce a great



Importance of keeping down weeds—another part of experiment illustrated on page 174. Ground plowed, seed bed prepared, weeds scraped with a hoe. Yield, 39.8 bushels.

(Illinois Agricultural Experiment Station.)

many seeds which have a strong vitality. Weed seeds may remain dormant for several years but when favorable conditions occur they germinate and develop into vigorous plants. The large number of seeds is an advantage to the weed because some of them are likely to fall in places where

they can develop into plants. A single tumble weed bearing 115,000 seeds, a square rod of ground in a garden where potatoes had grown the year before producing 187,884 weeds of eight different kinds, are examples of the great reproductive capacity of weeds.

A little observation together with the application of simple arithmetic will demonstrate the significance of the large seed production of weeds. For example, an Indian mallow has by actual count about 2480 seeds and occupies 315 square inches of space. If each of the 2480 seeds should produce a plant, there would be that number of plants covering a space of 20 square rods the second year. If each of these plants produced seeds at the same rate there would be, at the end of that season, 6,150,400 seeds. If each of these plants produced a plant the third year, the total area occupied by them would amount to 309 acres. Fortunately, for many reasons, no weed is ever so successful. But the illustration points out clearly the immense possibilities weeds have for multiplying their kind.

Another important contribution to the success of weeds is the means they have for the dispersal of their seeds. The common weeds not only produce seeds in great numbers, but many of them have very effective ways of scattering them about. When the seeds are light and provided with some means for keeping them suspended, like the seeds of the thistle or dandelion, they may be scattered by the wind. Or the whole plant may be broken off and driven by the wind from place to place, scattering seeds wherever it goes, as in the case of the tumble weed. Some weeds have seeds provided with barbs which are easily caught in the hair or wool of animals, and are thus carried about from place to place, as seeds of the burdock, cocklebur, spanish needle, sticktight,

beggar ticks, etc. Some seeds enclosed in the pulp of fruit are eaten and dispersed by birds. Examples of such plants are the poison ivy, and pokeberry and some of the night-shades, such as the ground cherry. Some weeds produce seeds that are light and almost impervious to water. During rains these seeds are carried about by the water and left at the edges of streams or on flooded land after the water has subsided. Some weed seeds, because of a similarity in size, are difficult to separate from the seeds of cultivated plants such as clover, timothy, etc., when they are threshed. For this reason the weed seeds may be planted along with the seeds of the crop to be produced.

Means of control of weeds. — There seems to be no practical way of entirely controlling weeds, but their effect on crops may be considerably reduced.

First in importance is clean culture. This means killing the weed seedlings as fast as they appear during the growing season. It is possible to do this when some cultivated crop, such as corn or potatoes, is produced. In discussing conservation of soil moisture, much emphasis was placed upon the need of frequent cultivation so as to maintain a good mulch. Indeed, recent experiments in Nebraska, Illinois, Ohio, Minnesota, Michigan, and by the U. S. Department of Agriculture seem to indicate that keeping the soil free from weeds is even more important in conserving moisture than using soil mulch. In farm practice keeping down weeds and making a soil mulch are usually done by the same operation. In an ordinary season when the rainfall is well distributed and not excessive, maintaining a good mulch will, at the same time, effectively control the weeds. In rainy seasons especial attention must be given to the removal of weeds. Uncultivated crops, such as wheat, should be grown in short

rotation with cultivated crops. For example, wheat following corn which has been kept free from weeds will be less injured by weeds than if following some uncultivated crop.

Other means of control that may be effective are heavy fertilizing to induce a vigorous growth of farm plants so that they may compete successfully with weeds; the use of animals such as sheep and hogs for control, the latter being especially useful in destroying bindweed; pasturing to reduce the growth of tall weeds thus permitting the development of pasture grasses; spraying with chemicals such as iron sulfate for wild mustard and wild onion.

It is also quite important that the seed of such crops as clover, timothy and wheat be free from weed seeds. All small seed used on the farm should be carefully examined for weed seeds. The purchase of seed badly mixed with weed seeds should be avoided.

When seed is produced on the farm it should be screened, several times if necessary, to remove the weed seeds. Many of our most troublesome weeds have become established on farms by the use of impure seed. For instance, the narrow leaf plantain was seldom seen in fields a few years ago, but becoming mixed with seed used on farms, it has grown to be a common pest.

All of our common weeds that are difficult to eradicate should be so well known that they may easily be recognized at any stage of their growth, and measures should be taken to destroy them. It is especially important to keep them from producing seed.

In most states the desirability of controlling weeds is recognized, and laws providing for their destruction on roadsides and in uncultivated areas are enacted. Because of the

ease with which weed seeds are carried from one farm to another some protection should be given to the careful farmer, but there is a great difficulty in enforcing laws. If all the farmers in a community would coöperate to exterminate weeds by using every means of control at their disposal, weeds would interfere much less with crop production.

CHAPTER XVII

INSECTS

The relation of farm practice to insect control. — It is a well recognized principle of field-crop pest control that there is a definite relation between farm practice and insect control, and that in many cases good farm practices alone are sufficient to overcome insect troubles. A recognition of the importance of insects, and a knowledge of their habits and life history and of certain relations existing between insects and their plant hosts will enable the farmer to plan intelligently his farm practices so as to reduce his insect problems to a minimum.

Insects both useful and harmful. — Not all insects are harmful. For instance, the bumble bee is essential to the profitable production of red clover seed and other insects are similarly useful in pollenizing certain plants. Other insects, such as the honey bee and the silkworm, are useful because of some product they make. Others are beneficial because of their destruction of insects that are harmful. The lady beetle, syrphus fly, lace wing fly, and many kinds of parasitic insects are examples of this group of insects. But there are many kinds of insects which are injurious because they interfere with crop production.

Extent of harmful insects. — A little observation during the growing season will lead to the conclusion that there are more kinds of harmful insects than useful ones. Each kind of plant will be found to be subject to injury by some kind of an insect, and many plants by many kinds. Among the plants, for example, which have special insect pests are

the potato — injured by the potato beetle; the cabbage plant — injured by the cabbage worm; the apple — codling moth; wheat — Hessian fly; corn — chinch bug; cottonboll-weevil.

Amount of injury by insects. — The total loss to agriculture in the United States, occasioned by insects, is enormous, amounting, according to good authority, at least to ten per cent of the total production. Thus in 1915, the wheat crop which amounted to about \$1,000,000,000 might have been worth \$100,000,000 more had it not been reduced by insect injuries.

The constant danger of damage by insects to growing crops is well illustrated by a reference to corn. "This crop may suffer from insect injuries from the time the seed is put into the ground until the meal is ready to use. The kernels just planted may be destroyed by wire worms, the young plants may die because their roots are eaten by wire worms or white grubs, or the juices of the roots may be sucked up by corn-root lice. If the plants escape destruction by these enemies, the soft stems may be injured by the burrowing of stalk borers, their leaves and stems pierced by bill bugs, or the whole plant cut off by cut worms. Should they still survive, the young leaves may be eaten by corn worms which may later attack the developing grains in the ears. Entire plants may be seriously injured, in May or June, by army worms, or a month later by chinch bugs as they come in from adjacent wheat and oat fields. When nearly mature, plants may fall over because the larger roots have been eaten by corn-root worms or cut in two by white grubs, or because the brace roots have been weakened by chinch bugs that have sucked away the sap. After the corn has been harvested and put into the crib, the kernels of the ears may be made

worthless by the larvae of grain moths. Finally, after coming from the mill, the meal may be made unwholesome by meal worms." Of course, it must be understood that not all of these injuries are likely to occur in any one season or to all the plants, but some of them are certain to occur.

Why insects are able to cause so much damage to crops. — Insects are generally small and may not be readily noticed except when they occur in great numbers. One may wonder why such small animals are able to interfere so greatly with farm production.

There are at least four great facts of insect life that help to answer this question. In the first place, there are many kinds of insects; second, they reproduce very rapidly; third, they grow rapidly; fourth, they are equipped to meet adverse conditions.

Kinds of insects. — The number of kinds of insects exceeds the kinds of all other animals put together. It is estimated that fully 400,000 kinds of insects are now known, while perhaps as many more have not been studied and described. In the reference just made to corn twelve kinds are mentioned. According to good authority as many as two hundred different kinds of insects may, at one time or another, attack and injure the corn plant. One hundred and twenty-six kinds of insects are known to injure the apple tree and more than five hundred, the oak tree.

Rapid reproduction of insects. — Not only are there many kinds of insects but many of the same kind. Enormous numbers of our common, destructive insects are produced each year. A little figuring will make clear the great reproductive possibilities of insects. If an insect should produce two hundred eggs, and half this number should develop into adults which, in turn, should produce the same number of

eggs per individual, there would be one hundred times two hundred, or 20,000 eggs; 10,000 of these might be females to begin the second generation. If these females should each deposit two hundred eggs, there would be 2,000,000 eggs, 1,000,000 of which might be egg-laying adults to begin the third generation, etc.

It has been found that a new generation of potato beetles occurs once each fifty days during the growing season. The possible descendants of one pair of potato beetles have been estimated at 60,000,000 for one season. Fortunately no kind of insect ever reaches its possibilities of reproduction. If it did, the world would soon be so filled with insects that there would be no room for other life. As a matter of fact, owing to various difficulties such as scarcity of food, diseases, insect parasites, birds, etc., the number of insects that get a chance to live is very small compared with the number that might develop if all conditions were favorable.

Growth of insects. — Rapidity of growth is perhaps the most important fact to be considered in relation to the damage done to crops by insects. For instance, some caterpillars which reach their growth in thirty days increase in size 10,000 times. At this rate, an infant weighing eight pounds would weigh as a full grown man 80,000 pounds, or forty tons.

In order to make such a rapid growth, insects must eat large quantities of food. It is not uncommon for a caterpillar to eat twice its weight in leaves in one day; often the rate of eating is greater than this. For example, one of our large caterpillars consumed in fifty-six days one hundred and twenty oak leaves, amounting to three-fourths of a pound.

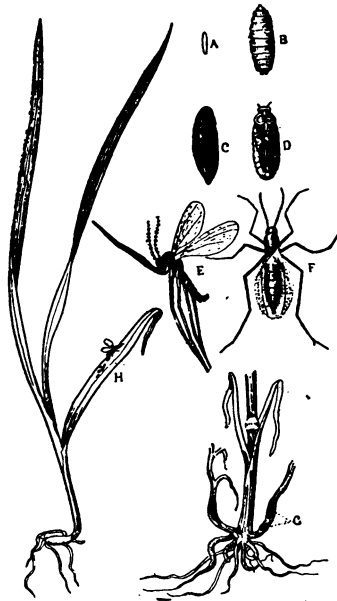
Insects are able to meet adverse conditions. — Another important fact of insect life is that they usually have a way of meeting adverse conditions. This bears on the question

of how insects interfere so much with farm production, though not so directly as those facts already considered. In general, their rapid growth and reproduction are means for

equipping them to meet unfavorable conditions. For example, where a large number of a certain kind of insect is produced, and conditions become unfavorable, more of them will survive than if the number produced were small. Rapid growth is also an advantage. It enables insects to make use of a food supply while it is plentiful, and thus rapidly pass into a stage during which little or no food is needed. For example, the young of the potato beetle eat much and grow rapidly for a few weeks, then pass into a resting stage, called pupa, in which they require no food.

In temperate climates, the most serious adverse condition which insects must meet is the cold of winter; but they meet this difficulty so successfully

that when spring comes there is enough to begin a new season. Insects pass the winter in various ways; some, like grasshoppers, survive in the egg stage; others like the cod-



Life history of the Hessian Fly.

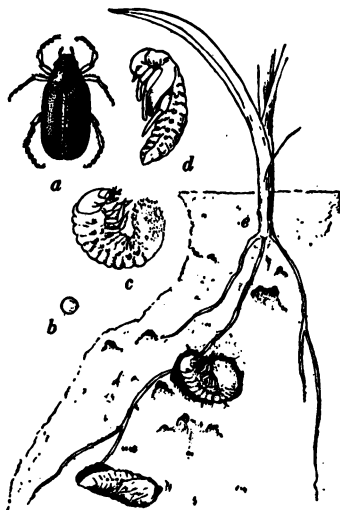
- a. Egg. b. Larva.
- c. Flax seed or pupa case.
- d. Pupa. e. Adult male.
- f. Adult female.
- g. Flaxseed on wheat plant.
- h. Fly depositing eggs on blade of wheat plant.

(Hanman: Missouri Agricultural Experiment Station.)

ling moth, survive as larvae; those like the cabbage butterfly, as pupae; those like the potato beetle, as adults; others, like the corn-root aphids, survive by some special means.

Insect life and insect control. — Having considered why insects are able to cause so much damage to crops, we need now to consider some facts of insect life which may help us to control this damage. Two facts are especially important: first, insects pass through definite stages of development; second, the way in which insects get food. Since both have a practical bearing upon insect control it will be of interest to notice each in detail, and to illustrate the application of this knowledge.

Life history of insects. — Most insects as the cabbage butterfly, housefly, May beetle, etc., pass through four stages in their life-history — that is, from egg to adult. The first stage is the egg; second, larva or active stage; third, pupa or resting stage; fourth, adult or mature stage. Some insects, like the grasshopper, make a short cut from egg to adult, omitting the larval and pupal stages. The young of such insects are much like the adult except in size and development of parts, particularly the wings. They are called nymphs.



Life history of May Beetle.

- a. Adult. b. Egg.
c. Larva. d. Pupa.
e. Plant showing grub destroying roots; pupa in burrow. (Hanman: Missouri Agricultural Experiment Station.)

It is important to know the life history of our common insects and also when and where to look for each stage, because such knowledge is needed for insect control. If the various stages in the life history of an insect are recognized, some one stage is likely to be found weaker or more easily reached than others. This should indicate what to do in order to prevent or reduce the injuries caused by this insect. For example, the codling moth lays its eggs on the small apples about the time the blossoms fall in the spring. Soon the egg hatches, and the larva, a little worm, eats its way into the young apple. Later, after the worm and the apple have increased in size, the apple falls to the ground. Then the worm crawls out of the apple and finally goes up the trunk of the tree to hide beneath some scale of bark. Here it changes into the pupa and later into a moth, ready to start a second generation. There are two points in this life history that suggest a means of control. First, the hatching period; if a poisonous spray is applied at this time the young larva is very likely to be poisoned as it eats its way into the young apple; second, the pupa-forming period, in mid-summer. At this time the worms crawl up the lower part of the tree trunk to find a shelter beneath the bark scales. If these scales are scraped off and a band of burlap is tied about the tree trunk two or three feet from the ground, the worms hunting for shelter will crawl beneath the burlap band. After they have collected under the band and formed pupae, it may be removed and the pupae destroyed.

How insects secure food. — It is important to know whether a particular kind of insect gets its food by biting or by sucking. If it gets its food by biting, the application of some poison in form of a spray will be effective for control; naturally the insect will eat some of the poison when eating

the poisoned plant tissue. If the insect gets its food by sucking, spraying with a poison will not be successful. The sucking tube of the insect by means of which it gets its food will penetrate the surface of the plant, and little or no poison will be taken into the body. Consequently other measures must be taken to destroy such insects. If a spray mixture is used, it must be one that will corrode or otherwise injure the bodies of the insects, such as the lime-sulfur mixture so commonly used to destroy scale insects; or one that will cover their bodies in such a way as to affect the breathing organs, such as the kerosene emulsion often used to destroy plant lice.

Sucking insects, such as scale insects, may also be destroyed by another method. The infected plant may be covered with a tent, and a poisonous gas, such as hydrocyanic acid gas, generated beneath it. The gas enters the breathing pores of the insects and they soon die.

What a farmer should know about insects. — The four great facts — many kinds of insects, rapid reproduction, rapid growth, and a successful means of meeting adverse conditions — should be recognized by the farmer in order that he may be on his guard and take measures for the control of insects.

The farmer should be familiar with the life histories of the most common injurious insects. At least he should know that caterpillars are the larvae of moths and butterflies, grubs the larvae of beetles, maggots the larvae of flies, that young grasshoppers resemble the adult forms except in size



San Jose Scale. Several adult insects considerably magnified to show details of appearance.

and development. He should be able to recognize the principal insects and the injuries caused by them to which his crops are liable. He should realize the importance of insect control to profitable farming. He should know the effects of rotations, arrangement of crops, time of planting, time of plowing, and the like on the important crop pests; the relation of moisture, climatic conditions, fertility, etc., to insect damage; the great importance of timeliness in recognizing insect troubles, and in taking measures for their control; and especially should he understand the value of calling upon his agricultural experiment station for assistance if the trouble is unknown to him or if he is not thoroughly familiar with the best methods of procedure.

What the farmer can do to control insect injuries. — The control of insects is an important and difficult task for the farmer, but there are many things he can do toward this control. It is to his advantage to know such facts of insect life as have already been set forth in this chapter. He should not only be able to recognize the various kinds of common insects but should have an acquaintance with their life-histories and habits. For example, if he knows by sight the moths of the army worm, and happens to notice that they are unusually plentiful in the spring, he will be prepared to see large numbers of the young later and perhaps be able to destroy them near their hatching grounds before they do much damage.

The following are some of the methods for controlling insect injuries:

Crop rotation. — The kind of rotation practiced may affect the kind and amount of insect injury to crops in the rotation. For example, as a result of the change from sod (grass) to corn, some of the insects, such as the white

grub, wire worm, and cut worm, which infest sod land may remain to injure the corn. Grass furnishes so much food that these insects are not usually noticed when the field is in grass, but they are numerous enough when the corn plants appear to do great damage to corn. This injury may be greatly reduced if measures are taken to get rid of the insects before planting the corn, that is, by early spring plowing and late planting. Another method would be to provide a rotation which would avoid using crops like corn to follow grass. Thus oats, clover, and corn would be a better rotation than oats, grass and corn.

Arrangement of crops on the farm. — The arrangement of crops in the fields has an effect on the control of destructive insects. Crops having the same insect enemies should not be planted side by side, for certain insects are likely to migrate from one crop to another. For example, a field of corn beside a field of grass might be injured by the army worms which come from the grass; but if the corn were next to a wheat field it would escape injury from these insects, for army worms are rarely found among wheat plants. On the other hand, if there were danger of injury from chinch bugs, corn growing next to wheat would be especially liable to damage by those insects, if they were numerous in the wheat.

Neither should crops having the same insect enemies succeed each other, for insects injurious to one crop are likely to live over to do damage to the succeeding crop; corn following grass, mentioned in a preceding paragraph, is an example. Nor should the same crop continue on the same ground two or more seasons in succession; the well-known occurrence of numerous white grubs and wire worms in old meadows and pastures, and of corn-root aphides and corn-root worms in fields where corn is grown for several years in succession are examples.

Timing farm operations. — The timing of work in the field has an effect on insect control. The value of timing farm operations is well illustrated by the success of measures that are practiced to protect wheat from injury by the Hessian fly. If a field in which the Hessian fly has been troublesome is to be used for wheat the following year, plowing and rolling the ground in summer and late sowing will usually save the next crop from much damage by this insect. Plowing and rolling destroy most of the insects, and the preparation for late sowing destroys the eggs of the flies that have escaped destruction in the first operation. A similar practice is followed in the control of the wheat jointworm. Where spring wheat is to be protected, burning the stubble and plowing in the fall, and early spring sowing are regarded as efficient measures. It must be understood that the Hessian fly and the jointworm are not always controlled by these methods. They should be employed, however, where rotation of crops which is a more effective means of control can not be followed.

Relation of moisture and other climatic conditions to insects. — Many insects are greatly influenced by climatic conditions, especially by moisture. This fact is worthy of consideration in insect control, for if conditions are favorable for their growth and development some measures for control may be necessary. For example, the greatest damage from the chinch bug may be expected during a hot, dry summer; and from the Hessian fly during a warm, moist spring or fall.

Soil fertility and insect control. — Keeping the soil fertile is a good practice not only from the standpoint of crop yield under normal conditions, but also from the standpoint of safeguarding the growing crop from a certain amount of damage by insects. Vigorously growing, healthy plants are less

likely to be destroyed by certain insects than those that are weak. For example, wheat plants that make an early, vigorous growth, as upon richly fertilized land, are less likely to be greatly injured by the jointworm than are weak, slow-growing plants. Mineral fertilizers and soil amendments such as kainit and lime seem to have a direct effect upon the control of certain insects. For example, insects infesting sod land may be partially controlled by heavy applications of kainit and lime. This treatment, when applied in the spring, has the added advantage of stimulating the growth of the grass.

Community coöperation. Certain insects migrate from one farm to another and therefore coöperation among the farmers of the community is necessary for the control of them. For example, wheat should not be sown early for pasture or volunteer wheat allowed to develop in wheat fields when the Hessian fly is bad. Such a practice is likely to injure the neighboring farmer who is making an effort to save his next crop of wheat from the fly.

Other methods of control.—Clean farming, including clean cultivation and the destruction of weeds and rubbish, has its influence in keeping insects under control. Corn shocks standing over winter may afford means of hibernation for chinch bugs; old cabbage stalks and leaves may furnish protection for the pupae of the cabbage butterfly and the cabbage maggot; weeds and other plants along fence rows and on other parts of the farm may harbor the Hessian fly, the chinch bug, the jointworm and many other insects.

Some varieties of plants are less liable to insect injuries than others. When possible such varieties should be used, provided they have other desirable qualities. The phylloxera of the grape vine, a plant louse injuring the roots and some-

times the leaves of this plant, will not do much if any damage to some varieties of the grape. A rapidly maturing variety of wheat would be likely to sustain less damage from the jointworm than a slowly maturing variety.

Natural enemies of insects. — Injurious insects, in spite of man's effort to control them, would soon become so numerous as to make agricultural production very unprofitable were it not for their natural enemies. These enemies are bacterial and fungal diseases; parasitic insects; birds; and mammals.

Insect diseases. — Insects like other forms of life are subject to disease, and when they have become diseased they are unable to cause further injury to growing crops. A few examples will illustrate insect diseases. A germ (bacterial) disease of the cabbage worm is not uncommon. In the course of the disease the worm ceases to eat and soon dies. The dead remains become soft and dark in color, and finally decay entirely. In late autumn, house flies may be seen attached to walls or window panes by fine threads of a mold-like substance. These flies have been attacked by a fungus. A similar disease sometimes attacks chinch bugs, destroying them in great numbers.

Parasitic insects. — An organism living on the body of another is called a parasite. The organism invaded by the parasite is known as the host. Nearly all insects are subject to injury by parasitic insects. The parasite usually lays its eggs on the body of the host. The eggs hatch into little grubs which enter the body of the attacked insect. Here they live until they find their way to the outside and form pupae. For example, tomato worms are often seen covered with the white oblong cocoons of parasites that have been living inside the worms. At this stage the worm is either dead or about ready to die.

Insects which are very numerous one season may be scarcely noticed the following season. It is probable that at the end of the first season most of them were attacked and killed by parasites. Consequently but few were left to start new generations the second year.

Birds. — Birds have been called “the farmer’s friends,” because they greatly aid him in destroying insects that injure his crops. The importance of attracting birds to the farm and encouraging them to live there is so great that the following chapter will be devoted to this subject.

Mammals. — The mole and skunk are common mammals that are useful in destroying insects, although at times they may become undesirable. The mole feeds upon worms, insect larvae such as wireworms and white grubs, and insects that live in the ground. The skunk eats a great variety of insects such as grasshoppers, crickets, white grubs, tobacco and tomato worms, and potato beetles. It also feeds upon field mice and other small rodents.

Learning more about insects. — Nothing can take the place of actually knowing insects, not from books, but by watching what they do, how they grow, where they live, when and where they lay their eggs and transform into the different stages of their development.

Such knowledge should grow by continued observation from year to year, with such assistance as may be obtained from bulletins and circulars, from state agricultural experiment stations and the U. S. Department of Agriculture, and from some good reference books on injurious insects.

CHAPTER XVIII

BIRDS AS RELATED TO AGRICULTURE

BIRDS rely largely upon weed seeds and insects for their food. For this reason they are of inestimable value in helping to control weeds and in holding insects in check. The good they do is not sufficiently appreciated. It will therefore be worth while to consider some of the facts of bird life as related to agriculture, showing how birds protect farm plants from insect injuries and from weeds to a certain extent.

Food of adult birds. — Most of our common birds are either seed eaters or insect eaters. In certain seasons they may eat fruit, but the damage done to cultivated fruits by birds is generally offset by the good they do in other ways.

Birds as destroyers of weed seeds. — We have seen that one reason why weeds are able to succeed so well in establishing themselves is that they produce great quantities of seeds. When weed seeds have been produced and scattered, little can be done toward control until they have developed into seedlings the following season. It is especially difficult to destroy seeds which have fallen on the ground. A large amount of weed seeds is eaten by birds. The number of seeds found in the stomach and crop of a bird, representing a single feeding period, gives some idea of the service rendered in the destruction of weed seeds. For example, a red-winged blackbird was found to have eaten in one feeding period 1800 seeds of ragweed; a bobwhite, 5000 seeds of pigeon grass; and a mourning dove, 9200 seeds of pigeon grass.

Among the seed-eating birds are sparrows, finches, grosbeaks, towhees, meadowlarks, and quail.

Birds as destroyers of insects. — One reason birds are able to destroy enormous numbers of insects is due to their ability to get quickly to places where insects are numerous. It may be noticed that an outbreak of grasshoppers is likely to be followed by an increase of birds in that locality. After the grasshoppers have been destroyed the birds pass on to some other place where insect food is more abundant. In this way insects are often kept in check and prevented from doing much damage.

The number of insects that a single adult bird will eat at one meal is very great, as the following examples will show. A yellow-billed cuckoo is known to have eaten 250 tent caterpillars; a nighthawk, 500 mosquitoes; another, 320 grasshoppers; a cedar waxwing, 200 canker worms; and a flicker, 28 large grubs. A scarlet tanager was found to have eaten 630 gypsy moth caterpillars in 18 minutes, and a warbler 3500 plant lice in 40 minutes. Among the birds that are largely insect eaters are the warblers, threshers, orioles, flycatchers, swallows, woodpeckers, thrushes, nuthatches, wrens, kinglets, vireos, creepers, titmice, and chickadees.

Birds as destroyers of rodents and other mammals. — Field mice, deer mice, rats, weasels, rabbits, and some other mammals are often very destructive of farm plants and farm products. With the exception of the rabbit whose numbers are usually kept down by hunters, the number of these harmful mammals is controlled largely by hawks and owls, and to a certain extent by crows.

The service rendered by many kinds of hawks and owls is not sufficiently understood and appreciated. Only two common species of hawks, Cooper's hawk and the sharp-shinned

hawk, are known to be harmful. These destroy other birds, and when occasion offers, poultry. Such hawks as the red-tailed and red-shouldered hawks, often called hen or chicken hawks, feed largely upon insects and rodents such as field mice. For example, an examination of the contents of the stomachs of twelve red-shouldered hawks showed that 102 mice had been eaten; while only three of 220 stomachs examined contained remains of poultry. Occasionally an individual hawk may get the poultry-eating habit. Such an individual should receive the same consideration as a sheep-killing dog. As a good protection against a hawk getting a taste for poultry, purple martins may be induced by the presence of nesting boxes to guard the poultry yard. The purple martin does not like the hawk and generally succeeds in driving him away. The presence of nesting kingbirds serves the same purpose.

All of our common owls seem to be beneficial, destroying enormous numbers of insects and harmful mammals. So much cannot be said of the crow. While it destroys many mice and other rodents it also destroys young birds, sometimes poultry, and often pulls up corn that is germinating in the fields.

Food of young birds. — Most of our common birds, whether seed-eating or insect-eating, feed their young almost exclusively on insects. Young birds grow rapidly and require an abundance of food. Many young birds digest their food in less than two hours. A young bird will often consume food equal to more than one-half its weight in one day. Three young chipping sparrows were kept under observation for an entire day and were seen to receive food from their parents 187 times; a family of young martins, 312 times; and a family of wrens, 600 times.

It happens that the first brood of young birds is produced

in the spring when insects are beginning to appear. This is a time when the destruction of insects gives the greatest protection to crops. Many adult insects are killed before they lay eggs, thus preventing in advance the damage a new generation might do. Again, countless young caterpillars and other insect larvae are destroyed before they are large enough to do much injury.

Bird population. — The effect of the decrease in the bird population in any agricultural region is shown almost immediately by the rapid increase of insects. On the other hand, injuries threatened by large numbers of insects are soon checked by the appearance of birds.

The importance of maintaining the bird population has been recognized in most states by laws protecting song birds and their nests. State laws have been greatly strengthened lately by national laws, both of the United States and of Canada, which are intended to protect birds during their migration periods.

A bird census or survey which was conducted in 1914 and again in 1915, under the direction of the U. S. Department of Agriculture, indicates that the kinds of birds, as well as individuals of each kind, are less numerous on farms than they should be for adequate protection against insects. These surveys show approximately an average of one pair of birds to each acre of farm land, an average much too low for the protection of crops. The facts of bird life, as shown by many observers in various parts of the country, point to a decrease in the bird population ranging from ten to seventy-five per cent in thirty states. It is not enough merely to protect birds from wanton slaughter. Some measures need to be taken to increase the number of birds, especially on farms. Among the things which encourage the presence of

birds on farms are trees and shrubs, provisions for nesting and control of bird enemies.

Trees and shrubs. — One of the chief causes of the decrease in bird life on farms has been the destruction of trees and underbrush and the clearing of waste places, all of which are natural bird haunts.

These have been, for the most part, necessary changes in order to enlarge the area of cultivated lands. But with the addition of more cultivated crops subject to insect injuries there is the need of more birds for protecting these crops. On many farms there are hillsides and other rough land that could be reforested. It is desirable to reclaim such regions in order to prevent loss of soil by erosion and to make them productive. Affording a place for birds to nest and to rear their young is an additional reason.



Bird house made of hollow limb of tree.
(After Forbush.)

Trees and shrubs around the farm home not only serve to beautify the home surroundings but they encourage the presence of birds of many kinds. There are several native trees and shrubs bearing wild fruits which furnish food for birds and, in this way, protect the cultivated fruit in the farm orchards. Birds seem generally to prefer wild to cultivated fruits.

The following wild fruits are regarded as useful in affording protection for cultivated varieties: for cherries — red mulberry, juneberry, wild red cherry, and red-berried elder; for raspberries and blackberries — dewberry, wild gooseberry and wild blackberry; for apples and pears — crab-apple, chokeberry and cockspur thorn.

Nesting sites and food for birds. — In addition to providing trees and shrubs as nesting sites for birds, nesting boxes placed in sheltered places will generally attract such birds as wrens and bluebirds. The practice of feeding birds in winter often encourages them to become permanent residents. At least a dozen different kinds of birds spend the winter in the Northern States. During severe weather, especially when the ground is covered with snow, these birds have a



Nesting sites for birds. Two martin boxes.

hard time to get enough to eat. Providing food at such times would prevent many from starving.

There are two rather common enemies of song birds that should be held in check. One is the English sparrow which is found almost everywhere. It generally succeeds in driving other birds away, and, as far as is known, does little by way of compensation. It should be trapped or poisoned during the winter. At this time there is the least danger of injuring other birds by these methods. A good summary of

means of control of the English sparrow may be found in Farmers Bulletin 493. Another foe is the domestic cat. It is said on good authority that one cat is responsible for the destruction of fifty birds in one season. Some cats may not be so destructive, but some are more destructive, so that fifty is thought to be a reasonable average. The cat has been a pet so long that it is hard to believe the evidence that has accumulated against it. Nevertheless, this evidence is too well founded to be disregarded. Much of the damage by cats occurs at night or early in the morning. The mother bird is caught on her nest, and the young birds before they are able to fly or just after they leave the nest. It is doubtful if the most careful feeding will prevent a cat from exercising its natural instinct to kill. If cats are necessary it has been suggested that each one should have a small bell tied to its neck to give warning to birds in time to permit their escape.

Appreciation of birds. — The interest in birds, the enjoyment of their song and beauty, the recognition of the service they render as allies in the conflict with insects and weeds, should spread in every farm community, so that birds will be encouraged to come there and build their nests and rear their young. This service can be given by boys and girls who are interested in birds, and who enjoy and appreciate them.

CHAPTER XIX

WHY RAISE FARM ANIMALS

Importance of farm animals. — The total number of farm animals in the United States for any one year is a good index of their importance as a farm product. For the year 1916 the values were estimated as follows:

Horses.....	\$2,150,468,000.00
Cattle.....	2,306,254,000.00
Sheep.....	254,348,000.00
Swine.....	571,890,000.00

Attention has been called to the fact that the demand for farm products is fast overtaking their production. This is particularly true of meat animals. For example, the number of beef cattle in 1900 was 50,083,777, but in 1916 was only 39,453,630; while the population had increased from 77,-256,630 in 1900 to over 100,000,000 in 1916.

Aside from the need of farm animals as indicated by demand and supply there is another equally important reason for their production. It has to do with a system of general farming which makes a profitable use of crops and of crop residue, and at the same time makes provision for maintaining the fertility of the soil. Farm animals are necessary for a system of this kind.

Soil fertility. — Crop farming has been shown to be not only less profitable than general farming, but more wasteful of soil fertility. Special farming, such as truck gardening,

orcharding and the like, requiring special knowledge and experience, has its place, but the market demand for such products may be supplied by relatively few farmers. The large majority of farms must be devoted to general farming. The manure produced on such farms, if properly cared for and applied to the soil, is of considerable importance.

Its value for keeping up the fertility of the soil has been discussed in detail in Chapter IV. When balanced with a phosphate of some kind, manure makes the best fertilizer. Besides it furnishes organic matter which is essential for maintaining a favorable soil structure, and for increasing the water capacity of the soil.

Disposal of crops. — The production of stock on the farm affords a ready means for disposing of various crops. This does not mean that no crops are to be sold for cash, but if all crops are sold there is a difficulty in keeping up soil fertility and a loss in crop residue that cannot be sold. On the other hand, if too much stock is kept some feed must be bought, often at a higher price than it can be produced on the farm. Extremes in either direction should be avoided. The most profitable kind of farming is usually one that combines live-stock and cash crops.

Crop residue. — There is always a crop residue such as stubble, corn stalks, and low-grade hay. There may be waste land which cannot be cultivated but which may furnish pasture. All this may be utilized in feeding some farm animals. Such feeding material becomes a source of profit instead of waste.

Labor. — The keeping of farm animals permits a good distribution of labor throughout the year. Where crops only are produced, a considerable portion of the farmer's time during the year is unemployed. The feeding and care of

live-stock requires most attention during a period when little work is needed for crop production. Animal production, therefore, fills a gap in labor employment. It makes possible a turning to profit of time which might otherwise be wasted. Furthermore, much of the care necessary for farm animals during the cropping season is given during mornings and evenings, thus allowing time for a good day's work. For these reasons live-stock may be said to be produced on cheap time.

System of farming. — If the balance between crops and animals is properly maintained in a well-planned system, such a system of farming is well adapted to the average farm. In this connection should be mentioned a kind of specialized farming — the raising of farm animals of a particular breed. Farms of this kind, in a limited number, are not only quite profitable when well managed, but are also an important source for supplying pure-bred animals for use on farms devoted to general farming. On such farms crop raising may be a secondary matter. In our discussion of farm animals their relation to general farming only will be considered.

Relation between production of crops and farm animals. — The advantage of establishing a cropping system for maintaining soil fertility and for control of weeds, plant diseases and insects has been shown in previous chapters.

A system of this kind is necessary for permanent agriculture. When farm animals are raised, a cropping system must be followed which will not only include these two provisions but a third also — one to meet the food requirements of animals. Fortunately this simplifies the problem of planning a system of farming, for, as has already been emphasized, animal wastes furnish an important means of maintaining the fertility of the soil. In general, farm animals

require a certain feeding balance which can be provided on the average farm.

We have seen why the production of farm animals is of great importance in supplying the needs of the Nation; and how it affords a good means of maintaining the fertility of the soil, of disposing of the farm crops, of utilizing crop residue, of employing farm labor to good advantage, and of making possible a system of farming which is generally profitable. We will next consider some of the main facts concerning the production of farm animals.

CHAPTER XX

HOW TO PRODUCE FARM ANIMALS

How farm animals are secured.—There are two ways in general practice of securing animals for the farm. One is by purchase, the other by raising them.

Many farmers do not attempt to raise their own stock, but buy it instead, especially beef cattle and, to a certain extent, sheep and hogs. Beef cattle bought as “feeders” illustrates this practice. The “feeders” are generally too much lacking in weight and finish for sale to packers. Their cost is considerably less per hundred pounds than the cost of cattle in a finished condition. The feeder, therefore, has two possible sources of profit: the gain in price per hundred between cost and selling price; and the gain in weight taken on by the animals during the feeding period. For example, if cattle weighing 900 pounds are bought at \$11 per hundred and sold at a weight of 1300 pounds at \$16 per hundred, for each animal there will be a gain of \$109. Part of this profit, \$45, represents the difference between the buying and selling price. This difference is sometimes called the spread or margin. The rest of the profit comes from the 400 pounds gain made by the animals. This amounts to \$64.

Importance of well-bred animals.—The same principles apply to the production of animals on the farm as to the production of high-yielding farm plants. Improved animals, or those that are well bred, are always more desirable than

scrubs or inferior animals. They are more profitable whether produced for meat, milk, or labor than those of inferior breeding. The advantage of good breeding is illustrated by the following example. A herd of twenty-seven dairy cows produced in one year an average for each of 3737 quarts of milk. This herd had been gradually improved and developed from animals that were about the average for the county in which the farm was located. The county average was low as indicated by the estimated yield which was annually but 1989 quarts per cow. Estimating the milk at four cents per quart, the gross income produced by the average cow of the county was \$79.56, while that of the average of the improved herd was \$149.48 — a difference of \$69.92 in favor of the latter. This is not an unusual incident. In almost any locality a comparison of the milk production of the average cows with that of improved stock will show a similar difference.

Feeding farm animals. — Success in live-stock production depends quite as much upon proper feeding as upon the selection of good animals. Indeed, well-bred animals respond better to careful feeding than those of inferior breeding.

Reference was made in a previous chapter to a feeding balance. Such a balance includes rough feed such as hay or pasture; concentrates which have a large starch content, such as corn; and protein feeds such as that furnished by clover and alfalfa. It happens that a crop rotation which will fulfill the first two requirements of a cropping system, mentioned in the chapter on Crop Production, will also meet the needs of farm animals. For example, a wheat-clover-corn rotation tends to maintain soil fertility through the clover, to secure freedom from weeds through the cultivation of corn, and to control plant diseases and insects through

a yearly alternation of crops on the same field. But at the same time this rotation furnishes roughage in the form of wheat straw and corn stover, concentrates in the form of corn grain, and protein and roughage in the form of clover. The rotation may be varied somewhat by using oats and timothy on small areas to take care of the special needs of work horses. In some such way the farm may be made to attain a high efficiency in production both of crops and farm animals, and at the same time may maintain this efficiency by keeping up the fertility of the soil.

Principles of feeding farm animals. — In order to secure the best results in the feeding of farm animals and also to furnish a variety of feeding material in sufficient quantities, it is necessary to follow certain principles of stock feeding established by experience and scientific study.

All farm animals need feed for two purposes; to supply energy, and to supply material for growth or for replacing parts of used-up tissues. The combination of feed materials used by an animal is called a ration, which also refers to the amount of feed used in one day. If the ration is just enough to keep the animal alive and healthy it is called a maintenance ration. But if, in addition to the amount needed for maintenance, it supplies a surplus for producing fat in hogs, milk in dairy cattle, or labor in horses, it is known as a productive ration.

A ration which meets the needs of an animal must contain three substances: protein, carbohydrates, and fats. Protein is a name given to a class of substances such as white of egg, lean of meat, gluten of flour, etc. Carbohydrate refers to starch, sugar, and cellulose; and fats to oily substances such as tallow, lard, butter, and to the oil of seeds, such as cotton seed, corn, etc.

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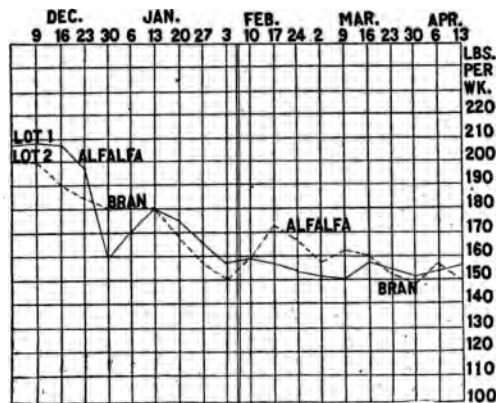
Carbohydrates serve the same purpose as fats; both are energy-producing feeds. But a given amount of fat produces about two and one-fourth times as much energy as the same amount of carbohydrates. In order to simplify calculations in the study of rations, it is customary to reduce fats to their carbohydrate equivalent, by multiplying the amount of digestible fat by two and one-fourth. The product obtained is added to the amount of carbohydrates, and the sum will give the total energy-producing material in terms of carbohydrates.

With these definitions in mind we will pass to their application. Two things should be taken into consideration: the composition of feeding-stuff, and the rations, called standard rations, that have been proved by experience and scientific investigation to be the most satisfactory for the various classes of farm animals. The problem is to secure for a particular animal a combination of feed material that will as nearly as possible fulfill the requirement of the standard ration. Such a combination should take into consideration the composition of the various substances used by animals as feed. All kinds of feeding material have been carefully analyzed and the results placed in tables for reference. In the appendix of this book is a table compiled from such sources, giving the composition of many common feeds.

Standard rations. — A standard ration is a certain combination of feeds adapted to a particular class of animals. Each standard ration has been developed through many years of experience in feeding farm animals, and through a study of experiments designed to show the effects of various combinations of feeds on different farm animals.

While the standard rations are by no means perfect, they furnish the best guide now available for intelligent feeding.

Sometimes the combination in the ration is expressed by merely indicating the ratio between the amount of protein and total carbohydrates (the latter including fats reduced to terms of carbohydrates). Such ratios are called nutritive ratios. They are expressed in this way: The first figure is always 1; the second is the quotient obtained by dividing the total amount of carbohydrates by the amount of protein.



Graph showing returns from cattle and hogs per \$100 worth of feed used on farms of various sizes.
 ————— Cattle. - - - - - Hogs.

(Figures from Missouri Agricultural Experiment Station.)

Thus if the ration contains three pounds of protein and twenty-one pounds of carbohydrates, the nutritive ratio is 1:7.

Although the nutritive ratio shows the desirable *proportion* between protein and carbohydrates, it does not indicate the amounts of each. A standard ration obviates this difficulty by giving the estimated amount of protein and of carbohydrates needed for each 1000 pounds of animal weight. Some of the standard rations will be found in the appendix.

Standardizing a ration. — A ration is standardized by comparing it with the standard for the class of animals to be fed, and then correcting it to make it conform to the standard. The ration to be corrected is called the trial ration. The trial ration may be one in actual use or may be a mere guess as to the probable needs of the animal for which it is intended. The following steps are necessary in standardizing a ration: First, by means of a table giving the composition of digestible feeds, determine the total dry matter, protein and carbohydrates in the trial ration; second, find the difference between each item of the trial ration and the corresponding item of the standard ration; then correct the trial ration to correspond closely, but not necessarily exactly, with the standard. An example will show how these steps are actually made in standardizing a ration.

A standard ration for cattle, per 1000 pounds live weight, first period, contains these nutrients: protein, 2.5 pounds; carbohydrates and fats, 16.1 pounds.

Suppose a ration of 20 pounds of red clover hay and 10 pounds of dent corn is being fed to a 1200-pound steer. Considering this as a trial ration the nutrients as determined from a table of digestible nutrients will be as follows:

<i>Trial Ration</i>	<i>Protein (pounds)</i>	<i>Carbohydrates and Fats (pounds)</i>
20 lbs. clover hay.....	1.42	8.3
10 lbs. dent corn.....	.75	7.24
	2.17	15.54
Standard ration for 1200-pound steer.....	3.00	18.60
Difference.....	.83	3.06

The difference shows the deficiency in protein to be relatively greater than in carbohydrates. Therefore the correction

should be made by adding feeds having a narrow nutritive ratio (one having a large proportion of protein), such as clover hay and a small amount of cotton-seed meal.

<i>Corrected Ration</i>	<i>Protein</i>	<i>Carbohydrates and fats</i>
25 lbs. clover hay.....	1.78	10.5
10 lbs. dent corn.....	.75	7.24
1 lb. cotton-seed meal.....	<u>.40</u>	<u>.40</u>
	2.93	18.14
Standard.....	<u>3.00</u>	<u>18.60</u>
Difference.....	.07	.46

The corrected ration conforms to the standard more closely than is really necessary in actual feeding practice.

In standardizing rations it is desirable also to pay some attention to the money value of the feeds used. Often an inexpensive feed which has the same feeding value as an expensive one may be used. Again, preference should be given to feeds grown on the farm, if they can be produced more cheaply than they can be bought. Here it is a question of deciding which is cheaper, home-grown or purchased feeds. For example, one farmer found that he could get the best return from his land and labor by raising potatoes and selling them, and then buying grain for feeding purposes. Making correct decisions in such matters is an important factor in successful farming. There are many things to take into consideration; conditions will vary in different localities and even on different farms in the same community. It happened that the farm just referred to was well adapted for potato growing and situated near a good market. Perhaps other farms in the same region were not so well suited for potato production and could not make such a system profitable.

Preparing and compounding a ration. — After the ration has been standardized it is an easy matter to prepare it.

A ration will always contain two parts, a bulky one, called roughage (hay is an example), another much less bulky, called concentrates (grain is an example). The roughage should be weighed separately so as to indicate the bulk necessary for one day's feed for one animal. After a little experience it is possible to guess closely enough to the required bulk of roughage without weighing it. The designated amounts of concentrates are weighed out in sufficient quantities to feed all the animals for one week, or perhaps a month, and mixed; the amount to be used for one day's feeding of one animal is then weighed from the mixture. Afterward the daily portion of concentrates may be guessed at with sufficient accuracy for practical purposes. The daily portions of both roughage and concentrates should be weighed from time to time in order to be sure that they are sufficiently accurate.

The standard is meant for an average animal of its class, but individuals vary somewhat in their feeding requirements. For this reason each animal should be watched closely, as it may be necessary to increase the ration for some and to reduce it for others. The greatest value found in standardizing rations is that it secures the right proportion of feed ingredients and forms a basis for feeding that will require least modification to meet the requirements of individual animals; but nothing can take the place of experience in feeding if results are checked by intelligent observation.

Care of farm animals. — In addition to having a sufficient amount of the right kind of feed, properly balanced, animals should also have good care; this includes regular feeding, access to plenty of water, salting, shelter for protection against cold and wet weather, and kindness in handling them. A careful observation of these demands is not only a humane

obligation toward dependent creatures, but may prove a source of profit as well.

Farm animals are more sensitive to irregular feeding periods than human beings. Regular feeding is important where it is a question of making an animal produce most efficiently and profitably, and not merely one of keeping it alive, as in "roughing" calves through the winter.

Water must be provided with the same regularity as feed. It is better to supply water so that animals may drink as much and as often as they desire.

Salt seems to be necessary to maintain the health of live stock. It is especially important for cattle and sheep. Salt should be given at regular intervals not too far apart. Some dairy farmers add a little salt to each daily ration.

Animals need fresh air but they should not be exposed to cold and wet. The comfort of the animal is not the only consideration. The heat necessary to keep the body warm and to evaporate cold rain or sleet from the body surface is generated by the feed eaten by the animal; therefore, the more the animal is exposed the more feed it will need. Consequently it is economic as well as humane to give farm animals shelter adequate for protection from bad weather.

It should be the rule to be kind and gentle in the treatment of farm animals. Such treatment is not only of benefit to the animals themselves but reacts also upon the person handling them.

Improving animals. — A reference was made in the first part of this chapter to the advantage of securing well-bred animals over using those of inferior breeding. In farm practice the method most used for improving live stock is known as grading. Grading is based upon selection, and by means of it an inferior group of animals may gradually be replaced by

better ones. If both parents are inferior, the offspring will tend to inherit the inferior qualities of both parents. But if one parent is superior, some of the superior qualities will be inherited by the offspring. A stock breeder — one whose business is to produce pure-bred animals — will see that both parents are superior, but such a method requires too much capital to be followed by the average farmer.

The average or general farmer can, however, afford to purchase from a reliable stock breeder a pure-bred sire; or several farmers may jointly purchase one. In this way may be secured one superior parent for the animals produced on the farm. The first generation of offspring will be better than the average of the original herd, and each succeeding generation will continue to be an improvement over the one before. As fast as the improved animals appear they may take the place of the inferior ones, which may be disposed of. In this way any group of farm animals, such as a herd of dairy cattle, swine, or sheep, may be graded up in a few years from inferior to superior animals.

Planning a cropping system for animal production. — The importance of a definite system of farming has been emphasized many times in one way or another. It is not an easy matter to plan and carry out such a system but it is essential for the greatest success. If we apply all that has already been presented in the discussion of the soil, crops, and feeding of animals, we find three things that seem essential in a plan for general farming: first, maintaining the fertility of the soil and improving soil conditions; second, producing as much of the necessary feed for animals as possible; third, providing some profitable cash crop, if soil and climatic conditions and facilities for marketing warrant. The principles which furnish a guide to the first have been presented

in Chapters II-VI. Some of the main facts concerning various crops that should be considered in selecting the ones for best production are given in Chapters VII-XI. The advantages of live-stock production in a system of farming and the general principles of such production have been considered in this chapter and in the preceding one. A fourth item in planning — the choice of animals that are to be included in the system — remains to be presented. In order to make an intelligent choice something should be known of the influence of various factors, such as size of the farm, markets, etc., upon the selection of the kinds of farm animals.

CHAPTER XXI

KIND OF FARM ANIMALS TO KEEP

THE choice of animals to keep on the farm depends upon several factors. There is no good reason to believe that one kind is always more profitable than another. One farmer may conclude that dairy cattle yield the greatest profit, while his neighbor may be equally sure that hogs are most profitable. Perhaps both may be right, for each man may know how to manage the animals of his own choice better than any other. So the first factor in determining a choice of live-stock is the personal preference of the farmer himself. The choice may be further influenced by the size of the farm, market facilities, lay of the land, and available capital.

Personal preference. — Likes and dislikes must be taken into consideration, for they are often based upon some past experience that may favor or hinder success. A farmer who dislikes sheep is not likely to succeed as well in raising them as another who is more interested in them. In some instances, no doubt, large profits may tend to change a farmer's attitude toward a particular kind of animal.

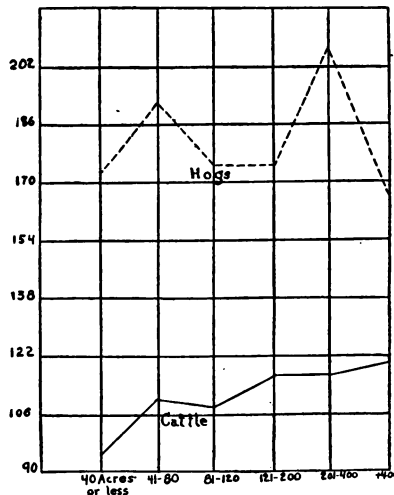
Size of farm. — As a rule small animals and small farms go together. A farm of forty acres or less would not be adapted to raising dairy or beef cattle, for it would not produce enough rough feed and pasture. But it might do very well for poultry, hogs, or even sheep. Large farms, on the other hand, are well adapted to raising beef cattle or horses, as

well as hogs and sheep. All the necessary feed may be produced on such farms, and the cost of keeping the stock may be much reduced by allowing the animals to have access to pastures and rough feed. A survey of a number of Missouri farms showed that on farms of 40 acres or less, the return for one hundred dollars worth of feed used was \$94 from cattle, and \$172 from hogs; but on farms of 121-200 acres, the return from cattle was \$115, and from hogs \$174. This seems to confirm the rule of small animals for small farms.

The relation of the size of the farm to the number and kind of farm animals is indicated in the following estimate giving the average number of acres necessary to support one animal: Horse, 3-5 acres; cattle,

per head, 3 acres; hog, 1 acre; sheep, $\frac{1}{2}$ acre. These figures are estimates only, but are sufficiently reliable to indicate approximately whether a farm is over- or under-stocked.

Markets. — The distance from market and the character of shipping facilities are of importance in making a choice of farm animals. A short distance to market is favorable for the shipment of all kinds of live-stock; a long distance entails shrinkage in weight and liability of loss by accident. Cattle and sheep stand long-distance shipping better than



Graph showing return from cattle and hogs.

hogs. Wool may be shipped any distance without much, if any, loss. This fact accounts, in part at least, for the production of sheep in several of the western states where the shipping points are remote from market. Milk and cream, being perishable products, must be marketed at frequent intervals. Dairy animals would not be a wise selection for farms remote from markets or shipping points.

Lay of the land. — The way the land lies — whether hilly or level — may determine the kind of live-stock best suited to a farm. Rough land can be used for pasture, while only level land can be cultivated. Sheep and beef cattle would do well on a hilly farm, if there were enough level land to furnish grain and hay for winter feeding. Low, wet land is not suitable for sheep raising, because such locations increase the danger of foot-rot and other diseases. High, dry ground, with plenty of pasture, is necessary for success in producing sheep. Hogs could not be used to advantage on hill land, because the pastures could not be utilized sufficiently. Dairy stock would not be likely to be profitable in a very hilly region, because of the difficulties in transportation of the products.

Capital. — There are two things that must be noticed in considering the relation of capital to the kind of farm animals to be produced: the cost or value of the individual animals; and the length of time that must elapse before the animals are ready for market. If the capital is limited, animals of low cost, such as sheep, hogs or poultry, should be selected; if a regular income is needed, dairy animals would yield products ready for sale each day. Sheep require from four to six months to bring in a return; hogs, six to eight months; beef cattle, six to ten months if bought as feeders, and one to two years if raised on the farm; horses, three years.

The lack of capital is one of the greatest drawbacks to keeping farms well stocked; local banks help solve the problem by lending money to farmers. The Federal Farm Loan Act (passed in 1916) is intended to furnish farmers with sufficient capital to enable them to extend their farm operations.

Types and breeds of farm animals. — So far our study of farm animals has been an attempt to answer three questions: Why keep them? How produce them? What kinds to keep? We need next to consider some of the main facts concerning the production of the great classes of farm animals. Each of the next six chapters will be devoted to particular problems concerning the production of one of these classes.

CHAPTER XXII

PRODUCTION OF BEEF CATTLE

FACTORS that must be considered in deciding whether or not beef cattle should be produced on a particular farm are the prospects for a continued favorable market, sufficient capital, and the character of the farm itself.

Market demands.— There are several reasons for the belief that the demand for beef cattle will continue to be as great as, or even greater than, at the outbreak of the Great War. The outlook, as it appeared in 1914, has been summed up by Professors Mumford and Hall, of the University of Illinois, as follows: "The undeveloped state of cattle production in proportion to the population and the area of the United States, as compared with the condition of the industry in older countries, justifies the expectation of an ultimate extension and development of cattle raising in this country. The rapid increase of population and the slower rate of increase in number of cattle have rendered the export trade a relatively insignificant factor; but with a large domestic demand in proportion to the supply and limited competition from abroad, the industry should be practically independent of foreign trade. General market conditions are now and promise to remain favorable to the producer, for he has a domestic market as a regular outlet and a foreign market as an influential regulator of prices and as an elastic consumer of surplus."

Capital. — Beef production requires a considerable investment of capital. Not only is the initial investment relatively large, but it is some time before a return may be expected — not until the cattle are sold. This time may cover a period of from one to two years if the cattle are to be raised on the farm, or from six to ten months if feeders are used. In many places farmers are able to secure financial assistance from local banks.

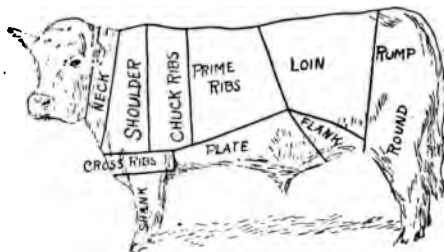


Diagram of beef animal showing position of various cuts of beef.

The Federal Loan Act already referred to is intended to aid farmers in financing such enterprises as beef production.

Farm conditions favorable to beef production. — When beef

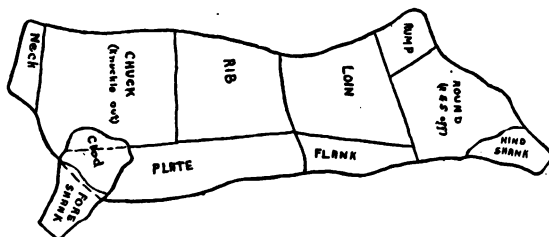


Diagram of side of beef showing wholesale cuts.
(Illinois Agricultural Experimental Station.)

cattle are raised on the farm the animals must be kept for a long period. For this reason low-priced land and low-priced feed are important factors in securing the greatest profit. The wide use of the western ranges for raising cattle is an application of this principle, and much of the broken land of

the east also fulfills these two conditions. In addition, if the cattle raised on the farm are to be finished for market, sufficient grain must be provided for this purpose. Some farmers raise their cattle on low-priced land and finish them for the market on grain and hay produced on the level and more valuable parts of the farm.

If feeders are employed in beef production, grain and roughage both must be supplied, and good farm land is necessary to furnish them. Many farmers of the Corn Belt, who own high-priced land, convert their products into beef by using feeders.

Raising beef cattle on the farm. — Among the points that should receive consideration are the kind to raise, development of the herd, feed-lots and buildings, feeding and management, and marketing.

Kind of cattle to raise. — Cattle are of two types, beef and dairy. A third type, known as dual purpose, is sometimes included. The latter is really a beef type, however, which has been developed for milk production. To attain success in raising beef cattle it is important to study types carefully.

Characteristics of beef cattle. — Certain parts of a beef carcass are more valuable for meat than others. The loin, rib, and round cuts constitute about one-half the weight of a carcass and possess more than three-fourths of the market value. Buyers of beef cattle desire animals with these parts highly developed. A study of figures showing wholesale cuts, and positions of these parts on a live animal, should be made in connection with the following table giving the wholesale prices of cuts. It will be seen from such a study that a beef animal should possess a good development of the loin, rib and round and a minimum development of shank and neck.

AVERAGE WHOLESALE PRICES OF CUTS OF BEEF AS QUOTED FOR
FEBRUARY, 1921

Cut	No. of lbs. (average per side)	Price per pound	Total price per cut
Round	90	\$0.19	\$17.10
Loin	80	.36	28.80
Flank	10	.10	1.00
Ribs	40	.24	9.60
Chuck	120	.12	14.40
Plate	20	.14	2.80
Front shank	10	.07	.70
	370		\$74.40

Quality.—The quality of beef, including tenderness, flavor, and cooking value, is largely determined by the distribution of fat. An even distribution of fat which gives the cut a marbled appearance is regarded as evidence of good



Loin cuts from steers of different market grades.

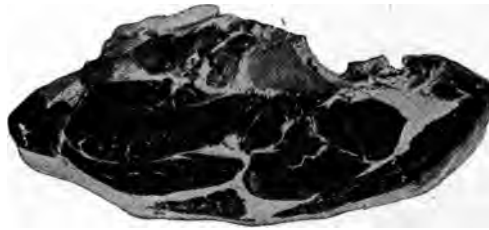
A. Common. B. Medium. C. Good. D. Choice.
(Michigan Agricultural Experiment Station.)

quality. The cuts represented in the figures of the text illustrate well and poorly marbled beef.

Dressing percentage.—The proportion between the weight of the carcass and the live weight of an animal, expressed in percentage, is called dressing percentage. For example, a steer with a live weight of 1100 pounds, producing a dressed carcass of 660 pounds, would have a dressing percentage of

60. The remaining 40 per cent would represent wastes, such as skin, feet, head, internal organs, loose fat, contents of stomach and intestines, etc., which are of little value compared with meat.

Dressing percentage is partly determined by the condition and partly by the conformation of an animal. One in good condition will have a higher percentage than one in poor condition; one having a blocky conformation, a higher percentage than one with an angular, paunchy conformation.



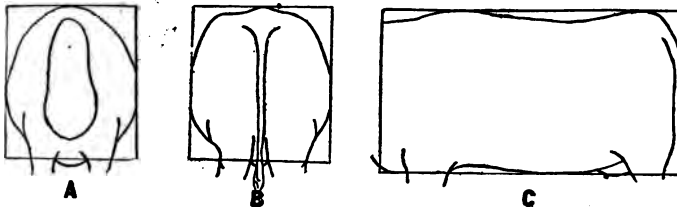
Loin cut of prime steer showing well marbled appearance of the meat.
(Illinois Agricultural Experiment Station.)

A beef animal in good condition should have a dressing percentage of 60 or more.

Economical gains. — The three characteristics just discussed are important from a buyer's standpoint. Animals having good distribution of flesh, indications of quality, and a high dressing percentage always command a higher selling price than those which do not possess such points. The farmer is interested not only in producing animals that will sell well, but that will also take on weight and condition for market with the lowest possible consumption of feed. This object is secured in part by intelligent feeding, but largely by a choice of animals capable of making gains with low

feed requirements. It happens that animals desirable from the standpoint of market demands for beef are, as a rule, able to make rapid and economical gains.

Conformation of beef cattle. — Experience has shown that a certain type of animal, known as the beef type, combines to a great degree the four desirable traits already described. The chief points that distinguish this type are as follows: The body is short and deep with top and underlines parallel; neck, short and thick; legs, short; ribs well arched and extending back toward the points of hips; thighs, full and deep;



Three aspects of a beef animal showing rectangular conformation.

- A. As seen from front.
- B. As seen from behind.
- C. As seen from the side.

shoulders and hips, smooth; skin, mellow and pliable; head, long and broad, with large muzzle and clear prominent eyes. A score card for judging beef cattle will indicate the various points in greater detail.

Breeds of beef cattle. — The specifications of the beef type just described will be met by a good representative of any of the common breeds of beef cattle. Although there is no one breed that can be regarded as best under all conditions, it will be worth while to consider somewhat in detail the leading characteristics of the four most important breeds: Shorthorn, Hereford, Aberdeen-Angus and Galloway.

Shorthorn. — A typical Shorthorn has width and depth of form and a generally symmetrical development. The head is wide between the eyes, but short from eyes to muzzle, the horns are short, curve forward gracefully and, in color, are waxy white with dark tips. The color of the Shorthorn varies from pure red to pure white. These colors are frequently mixed, producing a roan. Red, white, and roan



An example of the Shorthorn breed of beef cattle. Ohio Sultan.
(Plumb, Ohio State Agricultural College.)

may be regarded as the distinguishing colors of the Shorthorn.

The hindquarters are especially well developed — the best of any breed. The forequarter, on the other hand, is sometimes lacking in development.

Animals of the Shorthorn breed have a great capacity for the production of flesh, but come to full maturity later than other breeds. They are good feeders and are able to adapt themselves to a variety of conditions of climate and feed. They have a high rank among beef breeds, as milk producers.

Certain strains have been developed for the double purpose of milk and beef production.

The Shorthorn breed has been used more than any other in grading or improving common cattle. Shorthorn blood is usually much more in evidence in cattle markets than that of any other breed.

The hornless or polled Shorthorn, except for lack of horns,



An example of the Hereford breed of beef cattle. A Hereford steer, one-time champion of Ohio. (Plumb, Ohio State Agricultural College.)

is like others of its breed. It is generally known as the Polled Shorthorn.

Hereford. — The general conformation of the body of the Hereford is similar to that of the Shorthorn, except that it has a greater degree of smoothness of the shoulders and a better development of the loin region. The horns are whitish yellow, somewhat longer than those of the Shorthorn, and have a tendency to droop.

The color markings are quite distinctive. The head and

throat are white, with white extending over the breast and under the body. White also extends from the top of the neck to the middle of the shoulder. The rest of the body is red, varying in intensity from dark to light red.

The Hereford puts on flesh at all ages. For this reason it is a popular breed for the production of "baby-beef," i.e., cattle that can be put on the market between twelve and twenty-four months of age, weighing from 800 to 1200 pounds.

The breed is very hardy. It is also a superior grazer, having the ability to make a good growth on pasture alone. These characteristics probably account for the predominance of "white faces," as the breed is sometimes called, on the western ranges.

As a milk producer the Hereford is poor, the cows producing scarcely enough milk for their young.

Aberdeen-Angus. — This breed has all the characteristics of the beef type. Indeed, it may be said to approach closely the ideal of the beef type. The proof of this statement is indicated by the fact that this breed has been represented among the winners at the International Stock Exposition for a number of years and has topped the cattle market at Chicago, with one exception, each year for more than twenty years. The Aberdeen-Angus is an excellent feeder and matures early. It is less hardy than the Hereford and seems to reach its best development in the Corn Belt. It produces an excellent quality of beef and has a high dressing percentage. It is not a milk producer but ranks somewhat higher than the Hereford in this respect.

Galloway. — Like the Aberdeen-Angus, an animal of this breed has a short round body, is black in color, and has no horns. It is not likely to be mistaken for the Aberdeen-

Angus, because of its long shaggy coat of hair and rounded, instead of pointed, poll.

The Galloway does not reach as great size as other breeds. It is an economical feeder, especially in its ability to make use of rough feed and pasture. This characteristic, together with its extreme hardiness, makes it a desirable breed for certain parts of the west and north. In western Kansas, for example,



An example of the Aberdeen-Angus breed of beef cattle. An Aberdeen-Angus cow. Compare with cow of any dairy breed.
(U.S. Department of Agriculture.)

feeding experiments seem to indicate that the Galloway is superior to all other breeds through its adaptation to the rigorous climatic conditions of this region. Its flesh makes meat of excellent quality. It is next to the Aberdeen-Angus in dressing percentage.

In winter the hair is very thick and long, and the hide commands a high price. It is tanned and made into robes

that are said to be equal to the buffalo robes so common a half century ago.

The Galloway is a better milk producer than some of the other breeds but not equal to the Shorthorn.

Development of the herd. — Cows conforming to the beef type and a bull of the breed desired are necessary for the foundation herd. By employing the principles of grading discussed in Chapter XX, a herd of good beef cattle may be gradually developed.

Feed lots and buildings. — Beef cattle need little protection from cold, but require dry and comfortable quarters in which to lie. Muddy or frozen ground compels the animals to stand, thereby enforcing an expenditure of some of the energy derived from feed that might otherwise produce flesh. A feed lot with a southern exposure, provided with a shelter from rains and winds, meets the ordinary requirements. A covered feed lot not only gives good protection to cattle but has the added advantage of preserving the fertilizing value of manure.

Feeding and management. — In applying the principles of feeding already considered to raising beef cattle, the question of economy is of especial importance. Economy in feeding can usually be best attained by the use of pasture and leguminous forage, in summer, and roughage with some grain and leguminous hay, in winter. But in the final or finishing period a liberal amount of grain balanced with leguminous hay must be used. If the finishing period begins in the spring when there is good pasture, the grain ration can be much reduced, and the cost of finishing thereby diminished.

Aside from supplying feed or pasture, water and salt, it requires perhaps less attention to raise beef cattle than other farm animals.

Marketing.—A glance at the market quotations of a cattle market will show a wide difference in the prices of the various grades. The following reproduction of part of a daily market report will illustrate this point:

KILLING STEERS

Extra good, 1,300 lbs. up.....	\$13.75	@	\$14.00
Good to choice, 1,250 lbs. up.....	13.00	@	13.50
Common to medium, 1,250 lbs. up.....	12.25	@	13.00
Good to choice, 1,100 to 1,200 lbs.....	11.75	@	12.50
Common to medium, 1,100 to 1,200 lbs.....	11.25	@	11.75
Good to choice, 1,000 to 1,100 lbs.....	11.25	@	11.75
Common to medium, 1,000 to 1,100 lbs.....	10.50	@	11.25
Fair to good, under 1,000 lbs.....	10.00	@	11.00
Good to choice yearlings.....	11.50	@	12.75

STOCKERS AND FEEDING CATTLE

Good to choice steers, 800 lbs. up.....	\$10.00	@	\$11.00
Common to fair steers, 800 lbs. up.....	9.00	@	10.00
Good to choice steers, under 800 lbs.....	9.50	@	10.00
Common to fair steers, under 800 lbs.....	8.00	@	9.00
Medium to good heifers.....	7.00	@	8.00
Medium to good cows.....	6.00	@	7.00
Good to choice milkers.....	110.00	@	135.00
Fair to medium milkers.....	75.00	@	100.00
Stock calves, 250 to 400 lbs.....	7.00	@	10.50
Springers.....	7.50	@	9.50

Young animals, well finished but not too fat, and weighing from 1200 to 1400 pounds, meet the market demand for the better grades. The essential features determining a high-class beef animal, from the market standpoint, as presented in an earlier paragraph of this chapter should be referred to in this connection.

To secure the best return cattle should reach the market well finished after a short feeding period. A long feeding period is not only expensive, but, owing to the large amount of fat accumulated, the cattle do not always find favor on the market.

Feeders—Reference has already been made in Chapter XX to the production of beef by the use of feeders. The

discussion and illustrations should be reviewed at this point. It is a common practice of the farmers of the Corn Belt to buy range cattle at the large cattle markets, for use as feeders. When such cattle are bought they are full grown but thin. After a few months of feeding on hay and grain they are ready for the market. There are many systems of feeding, but they all make an application of the principles of feeding presented in Chapter XX.

CHAPTER XXIII

MILK PRODUCTION

DAIRY farming differs from other kinds of farming devoted to live-stock production, because the product as well as the animals producing it must be considered. Milk, butter and cheese will always be in great demand for they are almost indispensable foods. As the population of town and city increases the demand, the output of these products is likely to increase also. Since a steady market seems to be assured, the question of whether or not to produce milk for sale will depend upon other factors; of these the two most important are a means of disposing of the products, and a means of securing and utilizing labor.

Market and shipping facilities. — Milk and cream are highly perishable products; therefore, a location close to shipping points or to creameries is a first essential to success. On farms remote from a means of disposal the production of milk for sale is not a feasible farm enterprise.

Labor. — Labor is an important item in milk production. Although it is not fully employed it must be regular. It has been estimated that one man's labor is required for each twelve to fourteen cows. The size of the herd must depend therefore upon the help available. Since labor in milk production is only partly employed each day, and less is required in summer than in winter, some provision must be made to keep it fully employed.

To utilize this labor surplus to the best advantage is a problem of farm management permitting many solutions. The aim, however, is always the same — to secure the greatest net return from the entire farm. Many general or small dairy farmers use the surplus labor to produce feed needed for the stock and also to produce one or more cash crops to add to the farm income.

The difficulty of securing labor and using it to the best advantage is one of the greatest drawbacks to dairy farming and accounts, in part, for the small number of strictly dairy

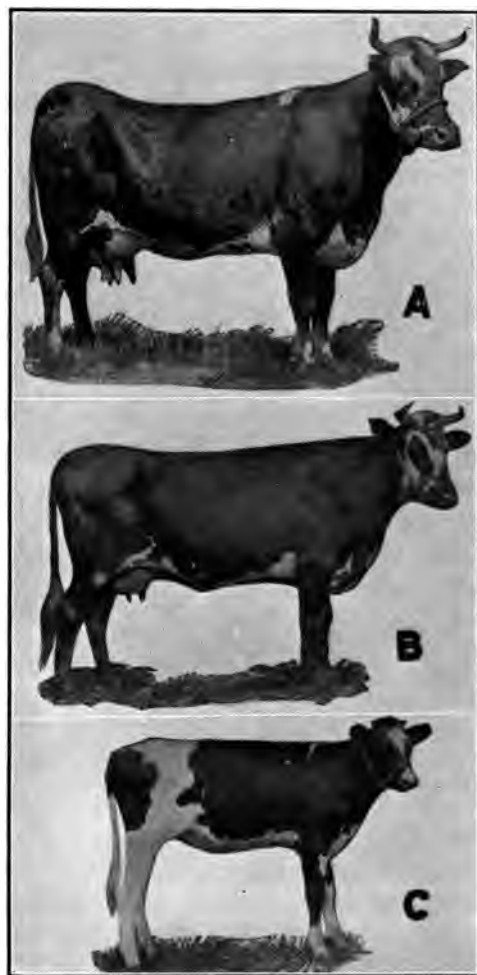


Diagram of three aspects of a dairy cow, each of which presents a wedge-shaped outline.

- A. As viewed from front.
- B. As viewed from behind.
- C. As viewed from side.

farms — only about six per cent of all the farms in the entire country. Most of the dairy products are produced on those farms where small herds of cows are kept, and where most of the income is derived from other sources. These small herds are fed largely upon crop residue and other low-cost feeds, and only home labor is employed. The return, although small, is almost clear gain and means so much added income.

Principles of milk production. — How to produce dairy products with the greatest profit is a problem of interest to the dairyman and also to every farmer who keeps cows.



An example of improvement of dairy cows by grading.

- A. Scrub cow. Best record, 4588.4 lbs. milk, and 210.67 lbs. of fat.
- B. Holstein X scrub cow, first cross, daughter of scrub shown in A. Four year old record, 6822.8 lbs milk, and 283.75 lbs. fat, an increase of 49 per cent in milk, 41 per cent in fat, and \$22.38 in profit over dam's best record.
- C. Second generation Holstein grade heifer calf, daughter of cow shown in B. Not until the second generation do most Holstein grades show white markings typical of pure breeds (Iowa Agricultural Experiment Station.)

This problem will be considered by taking up each aspect separately: first, the dairy herd; second, the handling and care of milk.

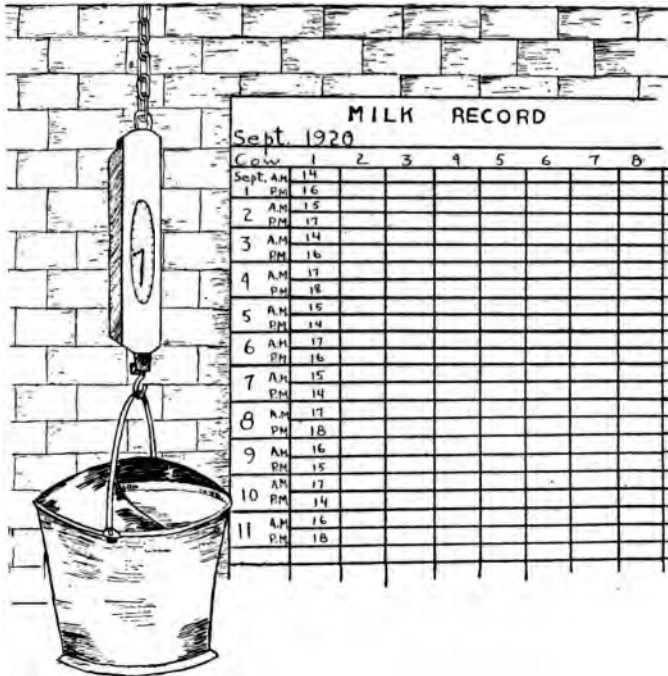
THE DAIRY HERD

Experience has shown that an economical production of milk depends chiefly upon the kind of cows, their proper feeding, and good management.

Kind of cows to keep. — The only accurate way to find a cow's value as a milk producer is to weigh her product at each milking, and to test the milk for butter fat at intervals, using the Babcock test. From the data secured, the value of her product may be compared with the cost of her feed and care.

However, there are certain characteristics associated with milk production that may indicate to some extent whether the animal is a good or poor producer of milk. These characteristics, based upon the physical requirements associated with producing milk, are the digestive system, which makes the feed ready to enter the blood; the circulatory system, which distributes nutrients; the respiratory system, which supplies oxygen and removes carbon dioxide and other gaseous impurities; the udder, an organ which takes certain material from the blood and makes it over into milk; and the nervous system, which coördinates and regulates the work of all the various organs concerned. A good representative of the dairy type should show a high degree of development in all these respects. In general, the conformation of an animal of the dairy type is in every way the reverse of that of the beef type. In the dairy type it is desirable that the feed should be used mainly to produce milk; in the beef type, to produce flesh.

The following are the most essential characteristics of a cow of the dairy type: she should be triangular in shape, as viewed from side, above and in front; spare, long, lean, narrow of head and neck; light in shoulder and sharp at



How a milk record is kept. Milk balances and record sheet are chief features. (Adapted from Cornell Agricultural Experiment Station.)

withers; broad in hindquarters but lean and spare; deep in chest, with ribs well sprung, wide apart and prominent; large in abdominal capacity, allowing room for well developed digestive organs; nervous in temperament — indicated by

spare and open conformation, absence of flesh, and prominence of bony parts; she should have a well-developed udder—extending well forward, fine, not too firm or meaty in texture.

The possession of all these characteristic points is an important indication of the value of an animal as a milk



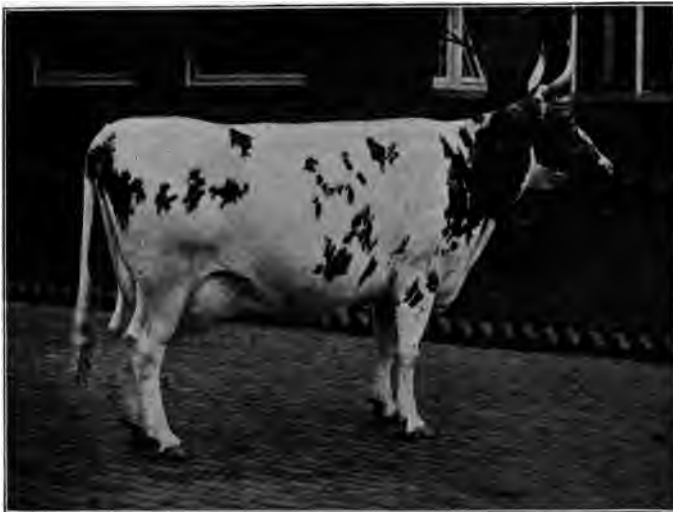
Holstein-Friesian Cow

producer, but should be regarded as an indication only, and should be checked by an actual production test.

The importance of emphasizing a high milk production in dairy cows is not sufficiently recognized by farmers. In Ohio, for example, according to census figures, the average production of the dairy cow is about 3500 pounds of milk annually. It requires approximately the value of 4000 to 5000 pounds of milk to pay for the proper care and food of one cow for one year. The figures for Ohio probably repre-

sent the average for the whole country. A few years ago, in Illinois, a careful study was made of the production of 36 dairy herds containing 554 cows. Of this number the best fourth yielded a profit of \$31.32 for each cow, while the lowest fourth gave a return of only 77 cents per cow. On this basis; it would take forty poor cows to yield the same profit as one good one.

The foundation herd may be gradually improved by elimi-



Ayrshire Cow

nating low-producing cows (using the Babcock test and milk records), and by applying the principles of grading. When grading the herd a well-bred sire will make an improvement even in the first generation. The influence of the sire is illustrated by the following examples. A scrub cow, whose best record was 3534.3 pounds of milk and 190.29 pounds of butter fat, produced a daughter with a record of 5137.7

pounds of milk and 251.85 pounds of butter fat. The sire was a pure-bred Holstein. On the other hand, a cow, yielding 4916 pounds of milk and 204.91 pounds of butter fat, produced a daughter whose record was 13 per cent less milk and 6 per cent less butter fat. In this case the sire was a poor one.

Breeds of dairy cattle.—Among the most important breeds of dairy cattle are the Holstein, Ayrshire, Jersey, and Guernsey.

Holstein.—The official name of this breed is Holstein-Friesian but it is commonly called Holstein. It is the largest of the dairy breeds. Its color is always black and white, varying in proportion in different individuals from almost pure white to almost pure black.

The Holstein ranks first in the quantity of milk production, but low in the percentage of butter fat. The strong points of the breed aside from high milk yield are vigor of constitution, good disposition, and its value for beef and veal.

Ayrshire.—This breed is next to the Holstein in size. An Ayrshire may be recognized by its red and white, or brown and white, spotted body and its sharp, erect, outward, upward, and backward curving horns. It is less angular than other dairy breeds, having smoother shoulders and fuller hind-quarters. The udder is said to be the most perfect of any breed, particularly the fore udder.

As a milk producer, the Ayrshire is not equal to the Holstein in quantity of milk, or the Jersey and Guernsey in percentage of butter fat. Its value for beef and veal is about equal to that of the Holstein.

Jersey.—Individuals of this breed are the smallest of the dairy breeds common in this country. The color ranges from light fawn to dark gray or black, the most common being



Jersey Cow



Guernsey Cow

fawn shading into black. Its milk production is low in quantity as compared with the Holstein, but high in percentage of butter fat. For beef and veal it is of little value.

The Jersey is sensitive in disposition, becoming docile and easily managed if treated gently, but the reverse if abused.

Guernsey. — This breed is similar to the Jersey in many respects. It is somewhat larger and more angular. Its colors tend toward reddish yellow or orange fawn, with white markings. The milk and butter produced by Guernseys have a higher color than that of any other breed. In quantity of milk and percentage of butter fat, this breed does not differ greatly from that of the Jersey.

Dairy Shorthorn. — A reference was made in Chapter XXII to the high rank of the Shorthorn as a milk producer. This characteristic of the Shorthorn is of especial advantage to the farmer who keeps but few cows. Cows of this breed will not only supply sufficient milk for his needs but also produce calves that can be developed into superior beef cattle.

Feeding dairy cattle. — The percentage of butter fat in the milk of each animal remains nearly constant, regardless of the amount or character of feed used, but a good ration may increase the percentage slightly. The quantity of milk, on the other hand, depends largely on the ration.

A maintenance ration, explained in Chapter XX, is about the same for all dairy animals of the same weight. But the productive ration varies according to the capacity of the animal for milk production — the larger the capacity for milk production, the greater the ration. The following table shows the nutrients required in a maintenance ration for cows of various weights:

<i>Weight</i>	<i>Protein (pounds)</i>	<i>Carbohydrates and Fats (pounds)</i>
600.....	.42	4.34
700.....	.49	5.06
800.....	.56	5.78
900.....	.63	6.50
1000.....	.70	7.23
1100.....	.77	7.95
1200.....	.84	8.67

The amount of feed added to that required for maintenance will be used chiefly for the production of milk. The extra feed should be sufficient to keep the cow at her fullest capacity of milk production. As a guide to the amount of each nutrient needed in a productive ration is given the following table of nutrients required to produce one pound of the various grades of milk:

<i>Butter fat, per cent</i>	<i>Protein (pounds)</i>	<i>Carbohydrates and Fats (pounds)</i>
3.....	.04	.224
3.5.....	.042	.246
4.....	.046	.271
4.5.....	.049	.305
5.....	.052	.327
5.5.....	.055	.340
6.....	.057	.364

By using the table it will be easy to calculate the amount of nutrients required to keep up milk production and percentage of butter fat, when the percentage of butter fat and the daily yield of milk are known. The entire ration will include the nutrients required for both maintenance and production. For example, if an 800-pound cow produces 30 pounds of milk testing 5.5 per cent of butter fat, she would

require for maintenance .56 pounds of protein and 5.78 pounds of carbohydrates and fats; for production, 1.65 pound of protein and 10.2 pounds of carbohydrates and fats. By consulting the table of nutrients in the appendix a selection of feeds may be made that will meet the requirements of the ration as calculated.

The standard ration forms a good basis for an intelligent feeding of dairy cows. It may have to be modified somewhat to suit individual cows, as some may require more, and some less, than the estimated amount. Often it is possible to increase the milk production of a cow considerably by bringing her ration up to what it ought to be. For example, by changing and standardizing the rations of a herd of poorly fed cows, it was found that the quantity of milk could almost be doubled, while at the same time the condition of the cows was greatly improved.

In making a ration to conform to the standard for dairy cows it is necessary to keep in mind the need of the animal for both roughage and concentrates. Roughage aids digestion by lightening and distributing the concentrates, which furnish most of the protein and considerable amounts of easily digested material, such as starch.

The most frequent mistake in feeding cows for milk production is a failure to give them enough feed. This mistake is often due to allowing roughage to constitute the main part of the feed. The animals may seem satisfied, but will not have a sufficient amount of nutrients to produce to their full capacity. Especially is this the case with the best type of dairy cows. The most profitable feeding, when milk production is the object, is liberal feeding.

Economy in feeding must also be taken into consideration; that is, the cost or value of the feed. In other words, the

requirements of feeding for milk production, as just set forth, must be met at the least expense.

In actual practice, summer and winter feeding present separate problems. In summer, the bulk of the feed is obtained from pasture. But ordinarily the nutrients obtained from pasture are not enough for the best milk production, and they should be supplemented sufficiently to bring the ration up to standard. The rations may be standardized by the addition of a concentrate, such as grain. The amount added may range from three to ten pounds, depending upon the size of the cow and her milk-yielding capacity; for example, three pounds for a small Jersey cow producing twenty pounds of milk daily, or, ten pounds for a large Holstein producing fifty pounds of milk daily.

In winter, the cow must be supplied with a palatable, well-balanced ration. Mixed feed, consisting of more than one kind of roughage including some succulent feed, such as silage, and several kinds of concentrates will tend to keep the cow up to her full productive capacity.

Among all the feeds best adapted for dairy cattle, silage has come to be recognized as the most important. It furnishes roughage and succulence, and approaches summer feed. It also reduces the requirement of hay and grain in the ration. For these reasons silage is very desirable in all rations for dairy cows.

An experiment was made at the Ohio State Agricultural Experiment Station to determine "what effect the feeding of more silage than is usually fed by dairymen, with a corresponding reduction in the grain portion of the ration, might have upon the production of milk, butter fat, gain in live weight, cost of ration, and consequent profit." Both rations conformed to the same feeding standard with almost the

same amount of digestible dry matter, but in one the nutrients were composed chiefly of concentrates; in the other, of silage. The silage consisted of one ton of soy beans and cowpeas mixed, to two and one-half tons of silage corn. The cows, similar in breeds and general condition, were divided into two lots of five each and were fed the different rations. The results showed the cost of milk per hundred pounds to be \$.687 with the silage ration, and \$1.055 with the grain ration. The cost of feed, per pound of butter fat, was 13.1 cents with the silage ration and 22.1 cents with the grain ration. Other experiments as well as the experience of dairymen seem to bear out the results of this experiment and point to the value of silage as a feed for dairy cows.

Silage has also been found to be excellent feed for beef cattle. It would seem well worth while for the general farmer, who feeds beef cattle and who also keeps a few dairy cows, to make use of the silo for providing the greater part of the roughage for his feeding.

Management. — It has been suggested that since cows reach their maximum production of milk in early summer, the conditions influencing this production should be reproduced as far as possible throughout the year. These conditions are chiefly an abundance of palatable and succulent feeds, moderate temperature, and comfortable surroundings. The first of these will be met by following the plan for winter feeding presented in a previous paragraph. The heat from the bodies of the animals, in well enclosed barns, will keep the temperature from becoming too low even in very cold weather, but it is also important to have the barn well ventilated. Good clean bedding and attention to cleanliness will do much to add to the comfort of the cows. Fresh water should be supplied in abundance.

Regular attention is of especial importance. This applies to time of milking, time of feeding, period for exercise and water in the winter, and for cleaning the stalls. Cows should not be disturbed when lying down during the middle of the day. Kind treatment should be the invariable rule. Dairy cows are usually sensitive and respond to gentle care and humane treatment.

HANDLING AND CARE OF MILK

Importance of clean milk. — The quantity of milk obtained is influenced by the kind of cows kept, and by their feeding. The quality of the milk depends upon how it is handled. Both quantity and quality must be considered if milk is to be produced with profit. Keeping milk clean, whether it is used to supply the farm home or is sold, is extremely important. If it is to be sold, milk which has been certified or guaranteed to be clean brings a higher price. Dirty milk may not be allowed to be sold at all. The farmer should be quite as careful with the milk that is used in his own home as he is required to be with that for sale.

The reason for placing so much emphasis upon the cleanliness of milk lies in the injurious effects that are known to follow the use of impure milk. Dirt is a source of real danger because of the bacteria that are always associated with it. It is now well known that impure milk is the cause of many digestive disorders, especially in children. Besides, other more serious diseases, such as typhoid fever and diphtheria, have been traced to a milk supply that was infected through the ignorance or carelessness of someone handling the milk. The effects of impure milk are regarded as being so dangerous

to health that the sale of milk is regulated in most cities. If impure milk is dangerous to people living in cities it is no less dangerous to those living in villages or upon farms.

How impurities get into milk. — Milk may receive impurities at every stage of handling from the moment it is drawn until used by the consumer. Particles of dirt and bacteria may get into the milk from the cow, during the movements of milking; from the dust of the stable or milk yard; from the hands and clothing of the milker; and from the milk pail or other containers if not thoroughly clean. The milk from cows suffering from udder troubles of any kind, or from those that give bloody or ropy milk, should not be used as food until the cows are cured.

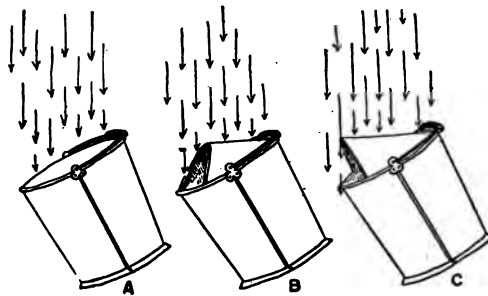
Much care should be taken to keep the body of the cow clean: First, the cow should be thoroughly groomed to remove loose hairs and dirt that might fall into the milk pail (grooming should take place long enough before milking time to allow the dust to settle); second, the udder and flanks should be wiped with a damp cloth, just before milking, to remove loose dirt and hairs. The need for this practice is emphasized by the following test made by the Illinois State Agricultural Experiment Station: Sixty trials were made at different seasons of the year. "With udders that were apparently clean it was found that an average of three and one-half times as much dirt fell from unwashed udders as after they were washed. With soiled udders the average was twenty-two times and with muddy udders the average was ninety-four times as much dirt from the unwashed udders as from the same udders after washing."

The stable. — The stable should be kept as clean as possible in all respects, should have plenty of well distributed light and good ventilation. Smooth walls and ceilings, water-

tight, easily drained floors, manure gutters, of the right size and properly spaced, are necessary to secure the best conditions for cleanliness. Sunlight is a good germicide and should have access to various parts of the stable. It also promotes the health of the cows.

Good ventilation is not only important for the welfare of the cows, but also for the purpose of removing odors that are readily absorbed by the milk.

Feeding, handling the bedding, and cleaning the stable



Types of milk pails

A. Open pail allowing free access to falling dirt.

B and C. So-called sanitary pails designed to reduce the amount of dirt falling into milk.

should be done in time to allow the dust to settle before milking.

The milker. — The milker should exercise cleanliness. His hands should be washed and carefully dried before milking. His clothes should be free from dirt that might be dislodged and get into the milk. Some dairymen require the milkers to wear clean white suits in order that dirt may be seen which might otherwise pass unnoticed.

Utensils. — The best milk pail is one that will allow the least amount of dirt to fall into the milk during the milking process. There are several designs of small-top pails that are good. Tests have shown that sixty per cent less dirt and twenty-five to ninety per cent fewer bacteria enter the milk when proper pails are used. Besides having a small top, the milk pail should be so constructed as to have all the joints perfectly smooth. Open spaces are almost impossible to keep clean.

To clean milk pails and the milk containers they should first be dipped into cold water to rinse off the film of milk; then washed, using a brush, with warm water and washing powder; and finally rinsed with boiling water and, when possible, sterilized with live steam or placed in the sun to dry where they will be free from dust.

Cooling the milk. — Under conditions favorable to their growth bacteria multiply very rapidly. Some reproduce as often as every half-hour. A small number, at this rate, would increase to an enormous number in a few hours. Warm, freshly drawn milk affords ideal conditions for the rapid development of bacteria. For this reason it is important to cool the milk as soon as possible after it is drawn, and to keep it cool. Various means are employed for this purpose. The best dairies use ice, but cold water is also effective. The container should be set in a tank of cold water, preferably ice water, and the milk stirred at least every ten minutes until the cooling process is complete; otherwise the center of the mass of milk will remain warm for a long time.

Tests as to the effect of cooling milk on its bacterial content and on its curdling period have demonstrated the effectiveness of the practice of keeping milk cool. When a sample was kept at a temperature of 45 degs. F., the number o

bacteria per cubic centimeter at the end of twelve hours was 9300, and the milk curdled at the end of 75 hours. When a sample of the same kind of milk was kept at 80 deg. F., at the end of twelve hours the number of bacteria per cubic centimeter was 55,300,000, and the milk curdled in 28 hours.

CHAPTER XXIV

SHEEP PRODUCTION

THE advisability of producing sheep on a farm depends upon the demands of the market, the general prospects for sheep production, and upon whether the particular farm affords conditions favorable for the profitable production of sheep.

Market demands. — The supply of lamb and mutton in the United States has been declining, while the demand, particularly for lambs, has been growing. The demand for wool is not so constant. The Western sheep ranges on which most of the sheep of the country are produced are being reduced in area, with a corresponding decrease in shipments. It is estimated that outside of the region of sheep ranges the present production may be increased three-fold without interfering with other live-stock production. This increase might be realized by a better utilization of land too rough for cultivation but suitable for grazing.

Conditions favorable for profitable production of sheep. — Sheep thrive best on high, dry land but do well on any land that is not too low and wet. They graze over wide areas and feed upon a variety of plants, preferring short, fine grasses to coarser plants. If the grazing areas are not large, forage crops must be provided. Fields for forage crops should be small or subdivided by temporary fences so as to afford a frequent change of grazing areas. This is necessary in order to

maintain the health of the flock. The chief feeding requirements are met if frequent changes of good pastures and grazing crops are provided for the open season, and leguminous hay for the winter. Some grain is needed, especially in the latter part of winter just after the lambs appear.

The feeding requirements can be secured on many farms that contain hilly land not fully utilized for grazing. Low-priced land and low-priced feed furnish the best combination for profitable sheep production. This applies both to raising lambs and sheep, and to fattening feeders.

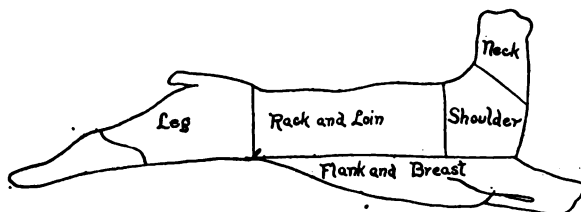


Diagram of side of mutton showing position of different cuts.
Note amount of leg and loin.

Stocking the farm. — As indicated in a previous chapter, farm animals may either be raised on the farm or bought for feeding purposes. Either plan may be followed in sheep production, but the former, perhaps, is the most desirable for most farms.

Raising sheep on the farm. — The kind of sheep to raise, getting a start, equipment, feeding, general care, and marketing are important matters to be considered in raising sheep on a farm. The kind of farm best suited to profitable production has already been considered in this chapter. But level farms entirely under cultivation, like the typical prairie farms of Illinois, have produced sheep profitably when combined with other stock production.

Kind of sheep to raise. — The selection of type and breed should take into consideration the kind of pasture and feed to be used, and the system of farming in which sheep raising is to be included. For example, if the farm is very rough and sparsely covered with grazing plants, some hardy breed, such as the American Merino for wool, or the Cheviot for both wool and mutton, would probably be the best selection. If the system of farming is one in which much grain is produced and other live stock raised, some breed of sheep that could clean up roughage and crop residues, and that would fatten easily when fed grain would be a good choice. The Shropshire, or some other medium-wooled breed, would answer this purpose.

It is usually wise to select the same type and breed already being raised successfully in the community, for there is an advantage in coöperation among farmers to secure superior breeding stock.

The following is a brief outline giving some of the characteristics of the common breeds of sheep. There are two types, corresponding to dairy and beef types of cattle — one being valuable mainly for wool and the other for mutton.

Wooled type. — Sheep of this type are frequently referred to as “fine wools” to distinguish them from sheep of the mutton type which also produces wool, less valuable because of its coarseness. The sheep of the fine-wooled type are probably descendants of the Spanish sheep known as Merinos, and “Merino” is commonly used to designate this type.

The Merino is characterized by its dense covering of very finely crimped wool, and when shorn, by its angular body. Merinos in America are of two breeds: American Merino, and Rambouillet or French Merino.

American Merino. — Sheep of this breed are of three classes, A, B, C. These classes may be distinguished by the

number of folds in the skin. Class A is most heavily folded; class B, less; and class C, sometimes called Delaine Merino, is nearly smooth except for folds around the neck. Sheep of the C class have coarser wool and larger bodies than those of the other two classes.

In weight and quality of fleece the American Merino is



Wool type of sheep. Rambouillet.
(U.S. Dept. of Agriculture.)

not equalled by any other breed, but as a mutton producer it is much inferior to mutton breeds.

French Merino or Rambouillet.— This breed was developed in France with the aim of securing a breed both for fine wool and mutton. It is much larger than the American Merino, but ranks lower in percentage of fleece to body weight and in fineness of wool. It fattens well and produces a fair quality of mutton, but as a mutton producer is not equal to mutton breeds.

Mutton type.— Sheep of these breeds bear the same relation to those of the woolled type as cattle of the beef type bear to those of the dairy type. Their conformation is similar to that of beef cattle — blocky with well developed back, loin, and hindquarters.

Mutton breeds are of two classes, long-wooled and medium-wooled. The former includes the Leicester, Cotswold, and



Heavy mutton type — long wool. Lincoln breed.
(University of Illinois.)

Lincoln; the latter, the Southdown, Shropshire, Oxford, Hampshire, Dorset, and Cheviot.

Long-wooled breeds.— Sheep of these breeds are large, with heavy fleeces of long, coarse wool. They are adapted to level regions and will do well on lands too low for sheep of medium-wooled breeds. They require for their best development an abundance of feed.

Medium-wooled breeds.— These breeds are valuable for the production of both mutton and wool, but chiefly for

mutton. The breeds vary considerably in their capacities for mutton and wool production. The Southdown is the smallest and is regarded as the most perfect of the mutton type. It produces a good quality of wool, but not a large quantity. It is well adapted to hilly pastures.

The Shropshire is medium in size and in fleece. It com-



Mutton type — medium wool. Shropshire.
(U. S. Dept. of Agriculture.)

bines many excellent qualities and is perhaps the most popular of all the mutton breeds in America.

The Oxford is the largest representative of the mutton type. It also yields the heaviest fleece among the medium-wooled breeds.

The Hampshire is nearly as large as the Oxford. It is lacking somewhat in the quality of mutton and fleece but has the ability to make rapid gains in weight, surpassing other breeds in this respect.

The Dorset yields a fair quality of mutton and a light fleece. Its lambs are produced earlier than others; hence it is valuable for raising spring lambs for an early market.

The Cheviot is an exceedingly hardy breed and is especially adapted for use on rough grazing land.

Making a start. — The principles of animal improvement as set forth in Chapter XX should be kept in mind and systematically carried out. Young ewes conforming as nearly as possible to the type desired should be secured for the foundation stock. The ram should be a good representative of the breed chosen. In a few years, through the process of grading, the foundation stock can be replaced by well-bred animals.

Equipment. — The most important equipment consists of buildings and fences. Dryness and good ventilation free from drafts are the main essentials to be provided in a building or shelter for sheep. Any building possessing these essentials will be satisfactory. Neither smooth nor barbed wire fences can be used to advantage because of the danger of catching the wool. A woven wire fence is perhaps the best; it not only makes a safe enclosure but also affords protection against dogs.

Feeding. — The general plan for feeding sheep has already been suggested in an earlier paragraph. During the grazing season provision for good pasture is usually sufficient. During the winter, plenty of roughage, including legumes of some kind to balance the ration, and a small amount of grain will meet the general feeding requirements.

General care and management. — There are many details in the care and management of sheep that must be omitted in this discussion for lack of space. A few principles only can be presented.

In summer, good grazing with frequent change of pasture, plenty of water and shade, and access to salt should be provided. If lambs are kept over summer they will need to be protected against stomach worms and other internal parasites. This may be accomplished by keeping the lambs separated from the older sheep, in uninfected pastures.

In winter, sheep provide their own protection against cold, but must be protected against wet and drafts by means of suitable shelter. They also need plenty of exercise. If they are kept in a large, dry feed-lot, they may be compelled to take sufficient exercise by scattering rough feed over the lot. When the lambs appear, in late winter and early spring, they must receive much special care in order to give them a good start in life. Especially is it necessary to look after weak lambs by providing warmth and food until they become strong enough to take care of themselves.

Marketing. — Experience seems to show that the greatest profit from sheep raising on the average farm is realized by having lambs ready for market at three to five months of age. An early marketing of lambs has these advantages: a saving of feed, and, usually, a high selling price; in addition, the risk of loss by internal parasites during the summer is avoided.

When the early market plan is followed, all the lambs are sold except those selected for addition to the breeding stock. During the following year the lambs which are retained will be ready to take the place of the least useful of the older ewes. The latter are then fattened and sold.

Feeders. — Instead of raising sheep to feed, some farmers buy them on the market, feed them until in good condition and then sell them. Most of the sheep in large markets come from the ranges, as at the Chicago market. When they

arrive at the stock-yards they are sorted; those in good condition are sold for mutton, and the rest are offered as feeders. The feeders are divided into several classes — feeder lambs, feeder yearlings, etc. Lambs are in greater demand for feeders, as they can be fed during the winter and shorn in the spring just before they are ready for the market. This practice affords three possible means of profit; the gain in weight during the feeding period, the margin of profit between buying and selling price, and sale of the wool.

It is seldom profitable to buy sheep raised on farms in the central, southern, and eastern states. Sheep coming from these regions are likely to be infested with internal parasites and are difficult or impossible to fatten. Western sheep, on the other hand, are rarely infested by parasites. Their poor condition is mainly due to lack of finish. When put on good pastures, or well fed, they usually make rapid gains.

CHAPTER XXV

HOG PRODUCTION

Hog production, as a farm enterprise, depends for its success upon the prospects for continued market demand and upon the capacity of the particular farm to furnish sufficient grain and forage for economical feeding.

Market demand. — In normal times, pork constitutes more than one-half of the meat produced in the United States. It is the chief source of meat and fat for a considerable portion of the population. Before the Great War (1910-1914) an average of 900,000,000 pounds was exported annually after home demands were satisfied. In 1917, 1,417,000,000 pounds were exported. The foreign demand for our pork will doubtless continue much beyond the years immediately following the war period, while home consumption is likely to increase as the necessity for food conservation grows less.

Conditions favorable to hog production. — The hog reproduces more rapidly and gains weight at less expense than any other meat animal. But in order to make the most of these two characteristics an abundance of feed is necessary. The first essential for successful hog production on a farm is to provide plenty of concentrates, such as corn, for feed. It is also desirable to have some leguminous forage crop, such as clover, to balance the ration and to reduce the cost. Hog production should succeed on any farm where corn can be raised cheaply. It is significant that the greatest

hog-producing states are in the Corn Belt. Hogs will do well in other states, but neither corn nor substitutes can be produced as cheaply as in the Corn Belt.

Stocking the farm. — Hogs are most frequently raised on the farm. Occasionally feeders are bought to be finished for market. But it is difficult to secure feeders, because it is usually more profitable for the owner himself to finish them for market than to sell before they are in market condition.

Raising hogs on the farm. — The chief factors to be considered in raising hogs on the farm are the kind to raise; getting a start; feeding; general care; and marketing.

Kinds of hogs. — There are two types of hogs, the lard

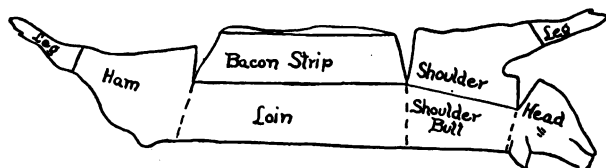
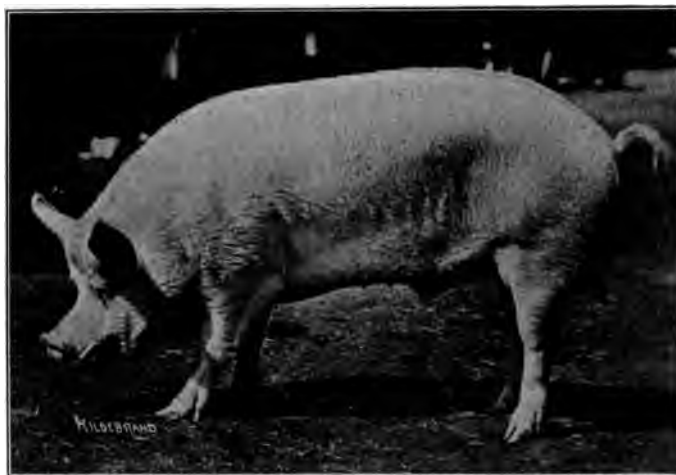


Diagram of side of hog showing position of various cuts.

type and the bacon type. At present in the United States, hogs are almost universally of the lard type. The predominance of lard hogs may be explained by the fact that they may be produced more economically than the same weight of hogs of the bacon type and have as good market value.

Generally, the wisest course is to choose the breed used by successful hog raisers of the community in which the farm is located. It is important, however, to be informed as to the characteristics and merits of the common breeds of each type. This information is condensed in the following summary:

Bacon type. — As the name indicates, hogs of this type are raised chiefly for the production of bacon; the side,



Bacon type of hog. Yorkshire. (U.S. Dept. of Agriculture.)



Lard type of hog. Poland China. (U.S. Dept. of Agriculture.)

therefore, is the important part of the animal and should be well developed. Such a development is found in hogs with long, deep bodies and light hams. In general appearance, bacon hogs are narrow in the back, long in body, light in shoulder and neck, and lean in flesh. The Tamworth and Large Yorkshire are the best representatives of this type. The Tamworth is red in color, varying from light to dark. It has a long, level back, long snout, long legs, and deep sides. The Yorkshire is white; its conformation is similar to the Tamworth except that the back is arched instead of straight.

Lard type. — The characteristics of this type are a compact form, short body, short wide neck, a broad back, deep sides, full hams, and short legs. The common breeds are Poland China, Berkeshire, Duroc-Jersey, Chester White, and Hampshire.

Poland China. — An animal of this breed presents all of the essential characteristics of the lard type. The chief distinguishing points are black color with six white markings — face, feet, and tip of tail; straight face, and drooping ears. It gains weight rapidly, frequently weighing 200 pounds at six months of age. The size of the litter is often small. In this respect the breed ranks low in comparison with others.

The large-type Poland China is a strain of this breed that seems to be gaining favor. It is more prolific than the standard breed, and it is claimed by many farmers to be superior in other ways.

Berkeshire. — Hogs of this breed are somewhat larger than Poland Chinas but are similar in some other respects. The color and markings are the same, but the face is sharply dishd, and the ears are erect or inclined forward. The flesh is lean fat — small in proportion. For this reason it

produces bacon of excellent quality. The Berkshire matures early and gains weight economically.

Duroc-Jersey. — This breed is similar in size to the Poland China and Berkshire. The color is cherry red but may vary in degree of intensity. The ears are drooped, and the face slightly dished. The litters are generally larger than those of the Poland China or Berkshire. This is an important advantage of the breed and accounts in part for its great popularity. It seems to equal other breeds in its ability to mature early and to make economical gains in weight.

Chester White. — In conformation, its length is about equal to that of the Poland China but its depth of body is less. Its color is white and the hair has a tendency to be wavy. It matures early, generally produces large litters, and is an economical feeder, being an especially good grazer.



Lard type of hog.
Berkshire — profile of head.
(University of Illinois.)

Hampshire. — This breed has been placed between the lard and bacon types. The flesh is similar to that of the Berkshire, of fine quality, with fat and lean well mixed. Its most striking characteristic is a white belt, four to twelve inches wide, encircling the body and including the fore legs, while the rest of the body is black. Some individuals are entirely black.

Getting a start. — The foundation herd should be composed of individuals that are good representatives of the breed desired. Uniformity should be the first consideration.

Feed lots and shelter. — Hogs should have a chance to keep healthy. With this end in view, they should be pro-

vided with well-drained lots not too much shaded, clean water, and sanitary houses well lighted and ventilated, which should be kept clean and purified with whitewash and disinfectants.

Feeding. — When applying the principles of feeding discussed in a previous chapter, securing gain in weight economically must not be lost sight of. The practice of feeding corn alone, so much followed in the Corn Belt, ignores the



Lard type of hog. Duroc-Jersey. (U.S. Dept. of Agriculture.)

need of a well-balanced ration and is expensive. The cost of producing pork may be lowered materially by using pasture and forage crops to supplement grain feed. Clover, alfalfa, vetch, soy beans, cowpeas, rye, oats, and rape are excellent forage crops for hogs. When non-leguminous crops are used for forage, they should be balanced by the use of some protein concentrate, such as tankage. If rapid gains are desired, a full ration of grain should be fed along with the forage; but if the greatest economy is to be practiced, the proportion of grain is reduced.

Grain and other concentrates are usually fed by hand, the amount of the ration depending upon the system of feeding followed. A method of feeding now being used with success by many farmers is to furnish the hogs with a constant supply of feed by means of self-feeders. A self-feeder is simply a container for concentrates such as corn, tankage, etc., and is constructed so as to allow the hog to eat as often and as much as it wants. "Hogging down corn" is another



Lard type of hog. Chester White. (U.S. Dept. of Agriculture.)

application of the principle of self-feeding. Two advantages are claimed for the use of self feeders; reduction of labor, and economy in the use of feed. The following summary of the results of some feeding trials makes clear the latter point:

<i>Number of pigs</i>	<i>Method</i>	<i>Average time, days</i>	<i>Average daily gain, pounds</i>	<i>Average daily feed per head, pounds</i>	<i>Average amount of feed per 100 pounds gain, pounds</i>
262	hand fed	82.2	1.23	5.47	445
332	self fed	68.5	1.92	8.00	417

General care and management. — When hogs have clean, comfortable quarters and sufficient feed of the right kind at



Lard type of hog. Hampshire. (University of Illinois.)



Judging pigs. Boys' Pig Club. (U.S. Dept. of Agriculture.)

regular intervals, their ordinary needs are met, and no further attention is necessary.

When the young pigs arrive some of them are likely to be

lost or injured, particularly if the weather is cold. Such losses may often be prevented by providing each sow with a brood house and dry bedding, and by seeing that the weak pigs are kept warm and receive proper nourishment.

One of the chief losses in hog raising is caused by hog cholera, which is responsible for 90 per cent of all the losses by disease. The total yearly loss for the entire country is estimated at \$30,000,000.

The danger of hog cholera and other diseases may be greatly reduced by providing the animals with clean water and clean, well-ventilated, frequently-disinfected quarters. If cholera appears, all healthy animals should be removed to clean freshly-disinfected quarters, and the old quarters should be thoroughly cleaned and disinfected; the bedding and all loose material likely to bear infection should be burned. The dead animals should be burned or destroyed by means of quick lime, and all places likely to be infected should be treated with fresh lime or some other good disinfectant.

Vaccination seems to be a good insurance against hog cholera, but it is not likely to be effective if hogs are kept under unsanitary conditions.

CHAPTER XXVI

FARM HORSES

Importance of the horse on the farm. — The horse plays an important part in American farming, where efficiency is measured by the production per man instead of production per acre as in some of the older countries. It is estimated that one horse properly directed will do the work of ten men and at one-half the expense. The horse and improved implements of farming have had much to do with the wonderful agricultural production of America.

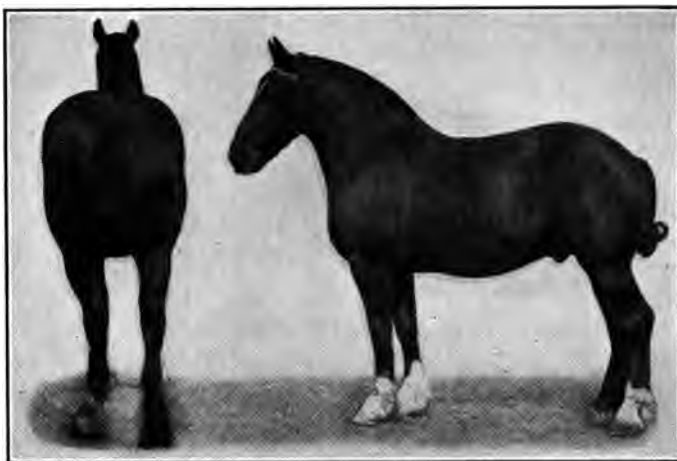
The automobile, the tractor, the truck, and power machinery are being used more and more by farmers, but much of the farm work will continue to be done with the aid of horses. The present difficulty, that of securing farm labor, will doubtless increase the value of the horse on the farm, for either machinery or horses will be needed for power.

The number of horses in the United States, according to the government estimate of 1918, was 21,563,000. This number is 1,133,000 greater than the average for the five-year period (1910-1914), and was maintained in spite of the very large shipment abroad of horses for army uses. The lover of horses need have no fear of their extinction. Doubtless there will be fewer of them seen attached to buggies and carriages on city streets and country roads, but they will be found on the farm doing the work that no other agent can perform so well.

While it would be of considerable interest in our study of

horses to take up types and breeds in detail, it seems more important to confine our attention to those that are regarded as the most useful on the farm, and to the essential points in the care of farm horses, such as housing, feeding, and treatment.

Farm horses. — Work horses have been roughly classified as belonging to four general groups, according to the work they seem best adapted to perform: 1. heavy draft horses useful



Farm draft horse. Side and hind views. (U.S. Dept. of Agriculture.)

for pulling very heavy loads; 2. medium and light draft, lighter than the heavy draft yet capable of doing heavy work (includes nine-tenths of all farm horses); 3. roadsters, adapted for drawing light loads with considerable speed; 4. small horses, known as ponies.

For farming purposes, only the first and second groups need be considered. The roadster has largely given way to the automobile, and the pony is of little value for farm use.

Whether heavy draft or light draft horses are the most

useful on the farm depends upon the work to be done. Light horses cover the ground quickly but are unable to pull heavy loads, especially over uneven surfaces or up steep grades. Very heavy horses do not work to advantage with light loads, or on soft ground, as in such operations as harrowing. The fact that about nine-tenths of all farm horses are medium, or light draft, is an evidence that experience has shown this size is best for general farm work.

In either case, size is not as important as the fact that animals should possess certain traits and characteristics. They should have a gentle disposition; should be easy to handle, with no bad habits such as biting, kicking, stall walking, fence jumping and the like; should be sound — free from defects decreasing efficiency, such as short wind, etc.; should be active rather than sluggish in movement; should have a good conformation (includes short neck, shoulders sloped sufficiently to form a good collar seat, broad and prominent breast, legs well shaped and well placed, feet and pasterns sloping but neither stubby nor flat, short back, closely set but with well-sprung ribs, and well-developed hindquarters).

Housing. — Proper housing for horses should include provision for ventilation, light, protection from cold and dampness, comfortable stalls, and means for feeding. A provision for good ventilation with freedom from drafts is the most important feature of a good stable. A safe rule for ventilation is to allow two cubic feet of air space for each pound of live weight. High ceilings furnish air space, save floor space, and make possible good ventilation and lighting. Windows with the sash hung near the middle afford light and an easy method of ventilation. Light should be admitted from the rear or side of stalls, not from the front.

In winter, horses do better when the stable is not kept too warm; the walls, therefore, should not be too tightly constructed. Tight walls not only tend to promote too much warmth in the stable, but also cause a condensation of moisture on the inside. Dry walls, open enough to allow air to pass through slowly, are the most satisfactory.

Stalls should be wide enough to allow grooming and harnessing of the horses. The partition walls should be strong. It is especially important to have tight floors which should be nearly level, with just enough fall for drainage. A floor with a greater fall than one inch in six feet is apt to put too great a strain upon the horse's legs. Wood flooring is regarded as the best kind if properly constructed. Cement floors are often used but they have the disadvantage of becoming slippery.

The arrangements for feeding should take into consideration the need for a rather large box for grain, so as to compel the animal to eat slowly. A small rack for hay will diminish the chance of over-feeding.

Feeding. — A sharp distinction must be made between feeding horses when idle or at light work, and when at heavy work. In the former case, a maintenance ration only is needed, but additional feed must be supplied to furnish energy for heavy work.

A standard ration for a horse lightly worked, per 1000 pounds live weight, is: 20 pounds of dry matter, 1.5 pounds protein, and 10.4 pounds of carbohydrates and fats, which gives a nutritive ratio of 1 : 7. A standard ration for a horse heavily worked is: 26 pounds of dry matter, 2.5 pounds of protein and 14.3 pounds of carbohydrates, which gives a nutritive ratio of 1 : 6. Individual horses will vary in their feed requirements, and standard rations should be varied to meet such differences.

Corn and oats are both satisfactory grain feeds for farm horses. Feeding trials made at the Agricultural Experiment Stations of Ohio, Missouri, and some other States indicate that there is both economy and efficiency in using corn. Oats, however, have long been considered a standard feed for horses.



Farm chunk. A mixed breed — draft predominating. Except for too great length of body, conformation good. (Illinois Agricultural Experiment Station.)

The choice between corn and oats perhaps should be based upon relative costs. The practice followed by many farmers of mixing the two grains has the advantage of giving variety to the feed, and is thought to give better results than either grain alone. For roughage, mixed hay composed of timothy and clover is very satisfactory. The clover, because of its protein content, helps to balance the ration of grain and

timothy; the chief objection is that it is dusty. If the hay is well shaken before it is put into the feeding racks, this objection will be overcome. The proportion of grain to roughage should be increased according to the amount of work done by the horses — the heavier the work, the larger the proportion of grain.

Since the horse has a relatively small stomach, he will require feed several times during the day. A good authority suggests the following methods for feeding work horses: first, one-fourth of the daily ration in the morning some time before the horse is put to hard work; another fourth at noon; a third fourth at evening after the horse has had time to rest and to eat some hay; the final fourth just before retiring time. In the second method, the first two feedings are the same as above; then after the day's work is over the horse may be allowed to eat hay for an hour or so, when the remaining half of the day's ration is fed. The hay ration should be given about the same time and in about the same proportion as the grain ration.

The proper watering of horses is as important as feeding. It is a good practice, during the working season, to let the horse drink before he is given his morning meal. He will then be less likely to over-indulge and thus interfere with his digestion. It is a humane practice to give the horse water in the middle of each working period, when he is doing hard work in warm weather. After coming from work he should be watered but should not be given too much, especially if his body is very warm; he should then be fed; a thirsty horse does not seem to relish his feed.

Care of farm horses. — When we consider that a considerable part of the cost of raising most farm crops is due to horse labor, the importance of taking good care of work

horses is apparent. Besides, such faithful workers deserve good care and good treatment.

In addition to housing and feeding, general treatment, driving, and grooming are essential matters relating to the care of farm horses.

No other farm animal, with the possible exception of the dairy cow, responds so well to kind treatment as the horse. Most farmers are well aware of this fact. They are very careful in handling their horses and do not abuse them in any way. But good treatment means more than freedom from abuse. It includes everything that makes for the comfort of the horse in his work, such as the use of well-fitting collars, bits that do not injure his mouth, a careful adjustment of the checkrein, proper methods of hitching to the load so as to reduce draft, etc.

In driving, a horse is controlled almost entirely by means of lines and bit. The horse's mouth should be kept sensitive so that he may respond readily to the slightest pull on the lines. Therefore, the lines should not be violently jerked or pulled. A good driver drives with "a light touch"; he does not pull the lines except when necessary and then just enough to make the horse understand what is wanted. It is said that there are very few good drivers. The fault lies in failing to appreciate the fact that the lines and bit are simply a means of communication between the driver and the horse.

A farm horse should be groomed to keep the skin in good condition. The legs of the horse should receive careful attention. They should be rubbed down vigorously after the day's work, especially if they are wet or muddy. Neglect to care properly for the legs of a horse may cause them to become stiff or permanently injured.

There are many other things that might well be included

in a discussion of the care of farm horses. Enough has been given, however, to furnish a basis for further study. In most communities there are farmers who treat their horses properly and who know how to take care of them. The methods used by those farmers will provide much of value and of interest for the pupil who is sufficiently interested in horses to want to learn.

CHAPTER XXVII

POULTRY RAISING ON THE FARM

Place of poultry on the farm. — There is, perhaps, no other class of farm animals that will thrive under so wide a variety of conditions as poultry. This great adaptability is shown by the fact that some poultry is raised on nearly every farm in all parts of the country. Their place on the farm, as with the farm garden and farm orchard, is to supply the farm home with wholesome food, and, perhaps, to furnish a surplus product for sale.

The attention required by fowls on the farm is small when compared with the return they give. The cost of feeding may be greatly reduced by utilizing table scraps, milk, grain, and other wastes, and in addition, these articles are disposed of to advantage.

Kinds of poultry. — The term poultry includes chickens, turkeys, guinea fowls, ducks, and geese, but is used sometimes to refer to chickens only. Some agricultural bulletins and other publications bearing the title "Poultry" have their contents devoted exclusively to chickens. The discussion of poultry in this chapter will be confined mainly to chickens, since they are of greatest importance and since the general principles relating to their production will also apply to other kinds of poultry. It will be of interest, however, to notice briefly some of the feeding habits of each kind of poultry.

Chickens have a great adaptability to general conditions, use a wide range of feeds, and are able to make good use of grain and other wastes of the barn lot or kitchen. They feed also upon insects, certain kinds of weeds, and weed seeds.

Turkeys have a wider feeding range than chickens. They forage almost entirely for themselves, using insects as their main food during their growing period. They require grain only when being prepared for the market.

Guinea fowls prefer to range in thickets and weed patches, in this manner making use of wastes not reached by other kinds of poultry.

Ducks and geese not only utilize the wastes of the barn lot but also make use of various pasture grasses. For the best success in handling ducks and geese, access to ponds or streams is desirable. Pond life, both plant and animal, furnishes a supply of food that other farm animals cannot use.

RAISING CHICKENS ON THE FARM

There can hardly be any question as to the desirability of keeping chickens on the farm, at least enough to supply the needs of the home. The main consideration is how they may be raised to the best advantage. The same principles must be applied which are successful in raising other farm animals. Careful attention should be given to selection of kinds to raise, feeding, housing, hatching, brooding, and general care of the flock.

Kinds to raise. — Two means of selection are employed in establishing a flock of chickens on a farm. One is to choose a dependable breed of the particular type desired. For example, if egg production is to be the chief aim in keeping a flock, some breed of the egg-laying type, such as the Leg-

horn, should be chosen. The other is to select individuals, that is, from the standpoint of vigor and constitution, for some fowls are weak while others are strong.

Types and breeds. — There are three types, each composed of several breeds. A brief description of these types with a mention of a few well-known breeds of each type will serve



An example of egg-laying type of poultry. White Leghorn male. (U.S. Dept. of Agriculture.)

to indicate the range of selection open to one who wishes to establish a flock of chickens on a farm.

Light or egg-laying type. — Poultrymen often refer to this type as the Mediterranean, because it originated in this region. These fowls correspond to the dairy-type of cattle or to the wool-type of sheep, in the respect that the product rather than the flesh is of chief importance. They produce eggs abundantly, but are too light

for meat production. Individuals of this type are small, very active, good foragers, and poor sitters. The Leghorn and Minorca are good representatives of this type.

Meat type. — It is known to poultrymen as the Asiatic type, because it originated in Asia. Fowls of this kind correspond to the meat types of other animals, since their chief value lies in the production of meat. They are heavy, sluggish in their movements, poor layers, and good sitters. They put on flesh readily when well fed, but are not inclined to

do much foraging for themselves. The Brahma and Cochin are well-known breeds.

General purpose type. — This is now generally designated as the American type, because it has been developed largely in America. Fowls of this type combine to a certain extent both egg-laying and meat-producing functions. They do not produce as many eggs as do those of the light type, or develop into as large fowls as the meat-producing type. Combining, as they do, the chief characteristics of each of the other types, and being vigorous and adaptable, they are found on farms more generally than the others. Among the best-known breeds are the Plymouth Rock, Wyandotte, Orpington, and Rhode Island Red.



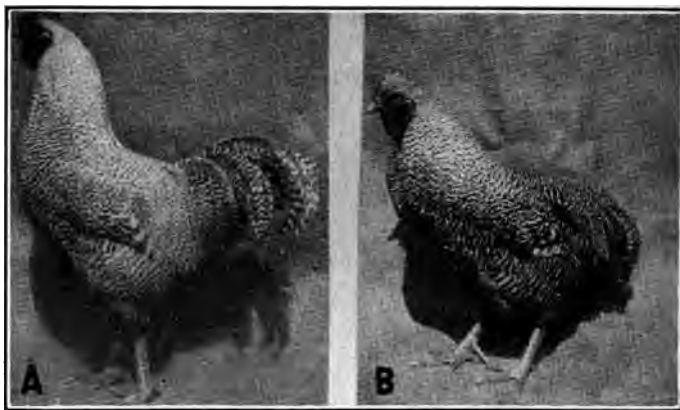
Constitution and vigor. — Individuals of any type or breed may differ

greatly. Some are of low vitality, and others are strong and vigorous. It is now regarded as much more important for an individual to have a strong constitution than to have the well-marked characteristics of a particular breed. Vigor and strength of constitution have to do with the health and mortality of the stock, the number of eggs produced, the percentage of eggs that will hatch, and the health and development of the chicks.

General purpose type of poultry. Barred Plymouth Rock male. (U.S. Dept. of Agriculture.)

Weak fowls, or those of low vitality may be distinguished by one or more of the following characteristics: long, thin beak and head; long, thin neck; slender body; long thighs and shanks. Strong fowls will have these parts well developed. A fowl of low vitality is also likely to be inactive and droopy, whereas one that is strong and vigorous will be active and alert.

Improvement. — Poultry, like other farm animals, varies



A contrast in constitutional vigor in same breed. Barred Plymouth Rock.

A. Strong. B. Weak.

(N. J. Agricultural Experiment Station.)

in the individual capacity for production. Pure-bred poultry, of whatever type desired, can be established without great expense and will usually prove more satisfactory than mixed breeds. All types and breeds have been developed by poultrymen to a high perfection for breeding purposes. The eggs of any type or breed may be obtained from such sources at small cost, and hatched on the farm. One cock and several

hens from such a hatching will form sufficient foundation stock for a pure-bred flock. When the flock has been established, it can be improved further by selection, particular attention being paid to vigor and constitution.

Grading is another method of improving a breed. It is similar to the method for grading a herd of cattle described in Chapter XX. For this method a pure-bred cock of the



Belle of Jersey, a little White Leghorn hen which laid during her pullet year 246 eggs and which consumed 40 times her own body weight to do this remarkable performance. (N. J. Agricultural Experiment Station.)

desired type and breed is necessary. Grading has the advantage of making use of the original stock of fowls on the farm, but it takes a longer time to secure a pure-bred flock of the desired breed.

What to feed. — The importance of proper attention to feeding poultry is indicated in the following statement made by the Agricultural Experiment Station of Purdue University (Indiana): "Records from commercial and farm flocks have shown profits that are being made, and when the methods

of management have been analyzed, proper methods of feeding have proven to be a very important thing to consider and know. Many a farm flock has proven unprofitable as a business proposition because of poor feeding methods. These same flocks have become an asset by simply changing and improving the ration and the methods of feeding them."

The general principles of feeding farm animals already considered (Chapter XX) apply also to feeding poultry. In applying these principles it is necessary to keep in mind the objectives in feeding poultry. These are growth, maintenance, production of eggs, and fattening or finishing for market. The following standards have been prepared as a guide for the first three of these objectives:

FEED REQUIREMENTS OF CHICKENS PER DAY FOR EACH 100 POUNDS
LIVE WEIGHT

(Geneva, N. Y., State Agricultural Experiment Station)

Birds	DIGESTIBLE NUTRIENTS (pounds)				Nutritive ratio
	Protein	Fat	Carbo- hydrates	Ash	
Growing chicks:					
First two weeks	2.00	0.40	7.20	0.50	1 to 4.1
Two to four weeks	2.20	.50	6.20	.70	1 to 3.4
Four to six weeks	2.00	.40	5.60	.60	1 to 3.3
Six to eight weeks	1.60	.40	4.90	.50	1 to 3.7
Eight to ten weeks	1.20	.30	4.40	.50	1 to 4.3
Maintenance:					
Hen, 5 to 7 lbs.	.40	.20	2.00	.10	1 to 6.2
3 to 5 lbs.	.50	.30	2.95	.15	1 to 7.4
Egg production:					
Hen, 5 to 8 lbs.	.65	.20	2.25	.20	1 to 4.2
3 to 5 lbs.	1.00	.35	3.75	.30	1 to 4.6

It should be remembered in making use of these standards that some feeds are better adapted for chickens than others, although the amounts of digestible nutrients may appear to

be nearly the same. For example, cottonseed meal contains a large amount of protein but is digested with difficulty; dry alfalfa feeds also are rich in protein but have so much crude fiber as to impair digestion.

In practice, proper nutrients are supplied by grains, mash, animal feeds, minerals, succulent feeds, and water. Grains supply energy for activity and heat, fat and material for yolk of egg. When scattered in litter the chickens are induced to take exercise necessary for maintaining health.

Mash is made by mixing finely ground mill by-products such as bran and shorts or middlings with animal products such as meat scraps. It is easily digested and supplies protein for restoring body tissue and for the white of the egg. The amount of animal feed used in mash may be reduced when sufficient skim milk or buttermilk can be supplied. One hundred pounds of milk are equivalent to about seven pounds of 50 per cent meat scraps.

Some mineral substance rich in lime and phosphates is needed to furnish material for bone development in growing chicks and for formation of shell of the egg. Grit has no direct nutritive value but is necessary to aid the fowls in grinding their feed. Sharp sand or "mica grit" prepared from granite is better than limestone grit which is too soft.

Succulent feeds are important for their tonic effect and their influence upon the health of fowls. A small pasture of clover or alfalfa will furnish succulent feed except during the colder months of the year when sprouted oats, mangels, or cabbage may be used.

The following ration for laying hens recommended by Purdue University is a good example of a well-balanced combination of nutrients:

<i>Grain</i>	<i>Mash</i>
10 pounds corn	5 pounds bran
10 pounds wheat	5 pounds shorts
5 pounds oats	3.5 pounds meat scraps
<hr/> 25 pounds total	<hr/> 13.5 pounds total

Economy may be secured by varying the proportions of this ration according to market prices; for example, when wheat is high in price vary the grain ration by using 18 pounds of corn and 7 pounds of oats.

How to feed. — Having considered the principles of feeding in some detail it is important to notice how to feed poultry to secure the best results. Two things are to be observed; the amount of feed should be sufficient and the ingredients should have the correct proportion.

The purpose of feeding, age, and breed of the individuals to be fed determine the proportion. If the object of feeding is to prepare fowls for the market, a larger proportion of carbohydrates and fat in the feed will be necessary. This may be secured by using more grain such as corn. If the object of feeding is egg production a large amount of protein will be needed. As to age, the older the fowls the greater is the tendency to put on weight; consequently the proportion of fattening feeds such as carbohydrates should be reduced except when finishing the fowls for market. Heavy breeds take on weight rapidly; if they are used for egg production the proportion of fat-forming feed should be lowered.

When egg production is the objective fowls should be encouraged to eat as much as they will. With healthy fowls there should be little difficulty in inducing them to consume feed up to their capacity. The real difficulty is to get them to use feed in the right proportion since they seem to find grains more palatable than mash.

The following practice suggested by the poultry department of Cornell University is a good summary of the essentials of how to feed laying hens: "The fowls should eat about one-half as much mash by weight as whole grain. Regulate the proportion of grain and ground feed by giving a light feeding of grain in the morning and about all they will consume at the afternoon feeding (in time to find grain before dark). In the case of pullets or fowls in heavy laying, restrict both night and morning feeding to induce heavy eating of mash, especially in case of hens. This ration should be supplemented with beets, ¹cabbage, sprouted oats, green clover, or other succulent feed, unless running on grass covered range. Grit, cracked oyster shell, and charcoal should be accessible at all times. Green feeds should not be fed in frozen condition. All feed and litter used should be strictly sweet, clean, and free from mustiness, mold, or decay. Serious losses frequently occur from disease, due to fowls taking into their bodies, through their intestinal tract or lungs, the spores of molds."

Housing. — The proper housing of poultry is often neglected. The prevailing notion seems to be that any kind of a shelter is good enough for chickens. This is far from true, for it is quite essential that they should have clean, dry, warm, well-ventilated quarters. Plenty of space should be provided, the general rule being four square feet of floor space for each fowl. A house six by eight feet and seven feet high will be large enough for twelve hens. Several houses small enough to be readily moved are sometimes more desirable than one large one. Plans and details for construction of various types of poultry houses may be obtained from the poultry department of any state agricultural college or agricultural experiment station.

Incubation. — Whether natural or artificial means of hatching are employed the object is the same — to secure a high percentage of vigorous chicks. The first essential is to use eggs of strong hatching qualities, that is, eggs produced by active, vigorous, carefully-tended breeding stock. Other essentials are correct means for hatching, correct methods of operation, and favorable conditions.

The choice between natural and artificial means of hatching depends upon several factors such as personal preference, equipment, and size of the flock. In some respects the natural method is superior — it is nature's method. With a flock of fifty or less this method is more economical than hatching by means of an incubator. The chief disadvantages are lack of control and the uncertainty of having an adequate number of sitting hens when wanted, especially if a large, early hatch is desired. The chief advantages of the artificial method are control as to time of hatching, ability to secure uniform conditions favorable for hatching, and for large flocks, economy. The chief disadvantage is the care and attention necessary for success. Where only a small number of chicks is wanted it is sometimes desirable to buy the young chicks from a commercial hatchery.

Natural incubation. — When applying to natural incubation the essentials mentioned in a previous paragraph they should include choice of the sitting hen, nesting place, and surrounding conditions.

The sitter should be chosen from general-purpose breeds such as Plymouth Rocks. Heavy breeds such as Cochins are too clumsy, and light breeds such as Leghorns are too unreliable.

The nesting site should be a place where the sitting hen will not be disturbed and one which will be easily accessible

to her as she returns from feeding. The nest should conform in shape to the natural nest made by a hen when she steals away to hatch her brood. It is an advantage to have the bottom of the nest made of soil in order to preserve its shape and to supply a certain amount of moisture to the air surrounding the eggs.

As a final preparation for incubation the nest and hen should be dusted with lice powder.

During the sitting period feed, water, and a dust bath should be accessible to the hen. At the end of seven days the eggs should be candled, those containing dead germs and the infertile eggs should be removed. After the chicks are from twenty-four to thirty-six hours old they may be removed to a coop.

Artificial incubation. — The efficiency of an incubator depends largely upon maintaining a uniform temperature at the desired degree (103). Four requisites have been suggested by Lewis, of the Poultry Department of the New Jersey Agricultural Experiment Station: "A sensitive, well-built thermostat; a simple but certain method of transmitting the action of the thermostat to the lamp; arrangements for easy adjustments or regulation; mechanism that will not get out of order with use."

Directions for setting up, caring for and operating the incubator are furnished by the makers of the best types and should be carefully followed.

Aside from following these directions attention should be given to turning the eggs, ventilation, moisture, testing, and care of the newly-hatched chicks.

In natural incubation the hen frequently turns her eggs. The object is to change the position of the germ which rests upon the top of the yolk, and to increase the supply of oxygen

to the growing embryo. The following rule should be observed (Lewis): "Begin turning on the evening of the third day, continue this process morning and evening, until the evening of the eighteenth or nineteenth day, or until the eggs show signs of pipping. Then prepare the machine for hatching, and do not remove the tray for any purpose."

Good ventilation is essential. A current of air should constantly move slowly through the incubator. As the method of ventilation depends upon the type of incubator it is usually a safe practice to follow the directions furnished with the machine.

Evaporation may be controlled by increasing the moisture in the incubating room and within the chamber. This may be done in several ways such as by frequent sprinkling of the walls and floors of the room, by using moisture pans under the egg trays, and by frequently sprinkling the eggs with warm water.

The eggs should be tested by means of a candler on the seventh day for infertile eggs, dead germs, germs adhering to the shell, and cracked eggs, and on the fourteenth day for dead germs.

From the time the eggs begin to pip the incubator should be undisturbed. At this time the nursery tray should be in place to receive the newly hatched chicks. After hatching the chicks may remain from twenty-four to thirty-six hours in the nursery tray, and then be removed to the brooder.

Care of chicks after hatching. — If the chicks are hatched in an incubator, a brooder must be employed to take the place of the hen. Essentially it is a box in which heat may be maintained and regulated in much the same way as in an incubator.

The brooder should be clean and the floor covered with fine sand over which short cut clover or grass has been scat-

tered. The first temperature should be 98° to 100° under the hover. After the second week it may be reduced to 94° or 96°, and in the fourth week to about 85°.

If the chicks are hatched by a hen, the hen and chicks should be transferred to a brooder coop about sixty hours after the hatch. The coop should confine the hen but allow a free range for the chicks. It should be sheltered from the wind, the floor raised slightly, and covered with sand to keep it dry and to aid in cleaning.

Next to clean, comfortable, well-ventilated quarters the most important factor in the care of young chicks is feeding to secure growth and maintain health and vigor. The first few weeks are a critical period. It is then that the greatest losses occur.

The Poultry Department of Purdue University suggests the following ration for young chicks:

<i>Scratch Grain</i>	<i>Dry Mash</i>
6 lbs. fine cracked corn	2 lbs. bran
4 lbs. fine cracked wheat	2 lbs. shorts
2 lbs. "steel cut" oats	$\frac{1}{4}$ lb. charcoal
Sour milk or buttermilk — all they will drink.	
Green feed — all they will eat.	
Grit (or sharp sand) and granulated bone before them at all times, hopper fed.	

"If milk is not available, $2\frac{1}{4}$ lbs. of fine beef scrap *must* be added to the mash, for rapid and vigorous growth depends very largely upon the amount and kind of animal food that is fed.

After the second week the above amounts of scratch grain and mash should be consumed in the same length of time. The ingredients of the above ration may be varied to suit local conditions and feed prices. If wheat and oats, as given above,

cannot be obtained, a good commercial chick scratch grain may be substituted or the grain ration may be made up largely of corn."

General care of the flock. — If the principles of feeding and housing are carried out little further care will ordinarily be necessary. The farm provides a good range in which chickens may forage for themselves, and they will also get plenty of exercise in this way. When confined, as may happen in winter, they should be compelled to take exercise. A good way to afford exercise for them is to spread straw over the ground in the enclosure and scatter grain through it, thereby obliging the chickens to do a good deal of hunting and scratching.

The health of the flock is an important matter. The first essential is to keep only those individuals showing vigor and strength of constitution. With ordinary care, that is, with good housing, plenty of feed and water, and proper exercise, vigorous fowls are likely to remain healthy. They are, however, sometimes troubled by parasites: a little worm that causes gapes, and body parasites — lice and mites.

The disease known as gapes is caused by small worms that get into the windpipe of the chick. It is often fatal to young chicks, especially if they are weak. As soon as the disease appears, all the well chicks should be removed to fresh quarters in order to avoid infection. The chicks that are affected may each be treated separately. The worms may be destroyed by inserting a drop of turpentine into the windpipe of the chick, by means of a quill; or they may be removed by twisting a broomstraw or loop of horsehair in the windpipe. The soil in the region of the infection should be plowed or dug up and then thoroughly limed.

Lice are especially injurious to young chicks and may also

seriously affect older fowls. Chicks infected with lice must be treated separately: The lice may be destroyed by greasing the head and body of the chick with a mixture of lard and kerosene, or by the use of sodium fluoride. Dust baths should be provided so that the hens and chicks may help to destroy the lice. Dust smothers the parasites by stopping up their breathing pores.

Mites trouble the fowl at night only. Keeping the housing quarters clean and spraying thoroughly and frequently with whitewash or with some good insecticide, so that all the places harboring the mites will be reached, are effective means of control.

After the breeding season is over, the cocks should be kept apart from the hens. The egg production will be as good but the eggs will not be fertile, and an infertile egg has better keeping qualities than a fertile one. So much loss is occasioned by spoiled eggs that every precaution should be taken to prevent it. Infertile eggs produced in clean nests and gathered each day are the least likely to spoil. Dealers in eggs are now protecting themselves by candling all eggs that are received, and eggs that show evidence of spoiling are rejected. This loss generally falls upon the producer who might avoid the loss with a little care.

CHAPTER XXVIII

FARM MANAGEMENT

What is meant by farm management.— There are two aspects to successful farming: production, and the disposal of products (which includes other business transactions). Production is based upon the proper adjustment of crops to soil and climatic conditions, and upon a proper balance between farm animals and the feed supplied by the farm. The principles underlying production have been considered in previous chapters, especially in those on Soil Management, Crop Production and in the introductory chapters on Farm Animals.

The business side of farming includes a system of organization which correlates production with disposal of products, and also includes a system of accounting or of keeping business records of receipts and expenditures..

Farm management deals with both aspects of farming. "It is not enough to raise good crops or to secure large animal production; these must be economically secured. This is accomplished only when capital and labor are so adjusted to existing conditions that maximum yields are obtained at the lowest cost. To farm successfully every department must be well organized and must be coördinated with others. Labor must be fully employed, capital must be well utilized, both quantity and quality of products must be secured and the products must be well marketed. All these things come

as a result of close attention to, and a detailed knowledge of, the business."

The real test of good farm management is to provide a fair income on the capital invested and a fair return as wages to the farmer. The difference between all the receipts and all the expenses represents the farm income. The labor income, or farmer's wage, is the amount of the income remaining after deducting a reasonable interest charge on the investment, say six per cent.

Example:

Capital invested.....	\$10,000.00
Interest at 6 per cent.....	600.00
Receipts.....	\$2500.00
Expenses.....	800.00
Farm income.....	\$1700.00
Deduct 6 per cent interest.....	600.00
Farmer's wage.....	\$1100.00

Many farmers fail to secure more than a small income on their investment and receive little return in wages for their labor. This condition may result from poor farm management or from the selection of a kind of farming unsuited to the particular farming region.

Types of farming. — When developing a farm organization, the type of farming best suited to the locality in which the farm is located is the first thing to consider. The chief factors concerned are soil and climatic conditions, and market facilities. If the kind of farming is not adapted to the soil and climate the business is likely to fail, no matter how well a farm is managed. For example, an attempt to raise hogs on hilly land may not be successful, however well the farm is

managed, if there is not enough level land to raise corn and other feed. On the other hand, the same farm might be profitable if sheep, which require less intensive feeding, were used; or if climate and soil were favorable, the farm might be successfully devoted to fruit raising. Level-land farming

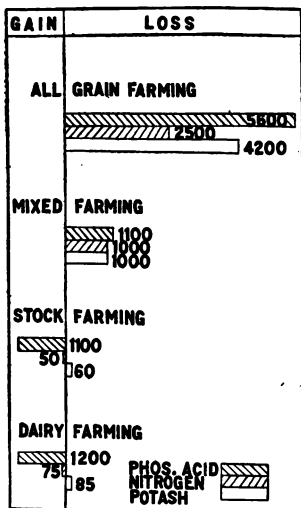


Diagram showing effect of type of farming on store of plant food in soil. Figures estimated on basis of 160 acres. Gain or loss expressed in pounds. (Adapted from Vivian: Ohio State Agricultural College.)

The effect of crop farming on soil fertility has already been pointed out. From a business standpoint, also, it has been shown by reliable investigation to be, as a rule, less profitable than stock farming. There are exceptions to this rule in some places; for instance, the great wheat-growing region of the Pacific Coast. But even here there are many

is seldom successful in hilly regions.

But a farm, under the best management and with a kind of production suited to soil and climate, still may not be made profitable, if it is devoted to perishable products and is remote from market.

Adaptation to soil and climatic conditions and market facilities are conditions for success which must be met in each of the three types of farming: crop farming, stock farming, and special farming.

Crop farming.—Crop farming usually refers to that kind in which 50 per cent or more of the total farm receipts are derived from the sale of grain or

places where grain farming might be combined profitably with stock farming.

The business disadvantage of crop farming, as compared with stock farming, may be seen by comparing the labor income of the two. A farm-management survey of 273 farms in Indiana, Illinois, and Iowa, showed the following result: The average labor income from 79 crop farms was \$28; that from 194 stock farms was \$755. This difference was exceptionally great because the price of corn was low during the year the survey was made. But an average for a series of years will show that the chances for a large labor income are against the crop farmer. There are two reasons for this: One is the greater average profit on crops when fed to stock; the other, the larger number of working days of the stock farmer as compared with that of the crop farmer.

If crop farming is followed from year to year on the same farm, it is absolutely essential that the organic matter of the soil be kept up by supplying green manure from such plants as rye or legumes and turning it under by deep plowing. Commercial fertilizers should also be applied to replace plant food taken from the soil. Even then it is not likely to be successful without application of superior knowledge of the principles of crop production and of good farm management.

On a California farm where wheat followed wheat continuously, the yield was 15.7 bushels per acre, but where rye was turned under by deep plowing and followed by wheat the yield was 52.3 bushels.

If the disadvantages, both from the standpoint of soil fertility and of actual profits, are so great in crop farming, the question arises as to why so many farmers follow this

type of farming. One answer is that they do not know how to farm differently. This is hardly a fair answer although it no doubt applies in some cases. The real explanation is that less capital is required for crop farming than for stock farming. Here is an advantage, the only advantage perhaps, that may be suggested.

Stock farming. — When engaged in live-stock farming the farmer markets his crops largely through farm animals such as hogs, sheep, and beef cattle. This type of farming has at least three advantages: It affords a means of maintaining soil fertility; gives a higher labor income; and provides for a good distribution of labor. The chief disadvantages are risk of losses due to diseases of animals, and the need of a large investment.

There is always a possibility of losing animals by disease, as, for example, the loss of hogs by cholera. But the risks may be lessened by observing proper measures for safeguarding the health of animals, or by securing protection through insurance.

The difficulty of obtaining capital is not so great as formerly, since the operation of the Rural Credit Act, a national banking law which became effective in 1916. It is now possible for a farmer to borrow money for the purchase of such things as live-stock. In many places it is customary for rural banks to give accommodation to farmers for the purchase of live-stock, the loan being repaid when the stock is sold.

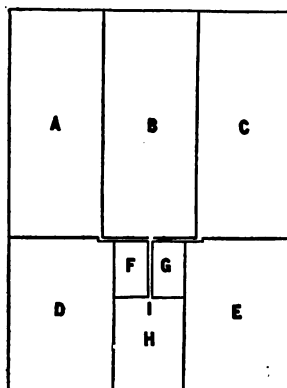
Special farming. — Special farming refers to the kinds of farming not included in the other two types: Orcharding, gardening, dairying, poultry raising, are examples. Many kinds of special farming are profitable, but generally require especially favorable conditions, such as soil and climate, or market advantages. The chief drawback to special farming

is that the profits are limited to one kind of production. If something goes wrong with this production, it is difficult to make adjustments so as to prevent losses. In stock farming, on the other hand, unfavorable conditions may be met by selling the stock and relying temporarily on the sale of crops for an income.

Diversified farming. — While one of the preceding types is followed as a main line, at the same time another type may be employed. For example, while dairying may be the chief interest of the farmer, he may produce also certain cash crops, such as potatoes. In this way, his labor may be more fully utilized, and possible losses due to unforeseen circumstances partly offset. There are several combinations that seem to be successful, such as stock farming and orcharding; wheat farming and stock raising; cotton farming and dairying; etc. Combinations like these require more attention to organization and management

than is necessary for a single type, but they offer greater flexibility or more ready adjustment to losses or failures occasioned by unsuspected conditions, such as an epidemic of disease, very unseasonable weather, poor markets, etc.

System or organization. — Whatever the type of farming followed, it should be systematized and organized, and then



Plan of arrangement of fields on a farm.

A, B, C, D, E Fields.

F, G Feed lots.

H. Farmstead — yard, garden, orchard, barn lot, etc.

I. Lane leading to fields.

Such a plan may be modified to apply to farms of various sizes and shapes. The essential features are convenience to fields, shape of fields, and economy of fencing.

carefully managed so as to carry out the system. The organization must take into consideration, first of all, the conservation of soil fertility. For the soil represents capital just as much as money invested in the business does, and the same care should be taken to maintain it as is exercised in maintaining the cash capital invested. Just how the fertility of the soil may be kept up will depend upon the application of the principles of soil management, already discussed, to the type of farming employed.

In crop farming, it will be by rotation of crops and by the use of green manure and commercial fertilizers; in stock farming, it will be done by making use of barnyard manure and crop rotation; if it is special farming devoted to plant production, it will be done by purchasing manure and commercial fertilizers. The distribution of labor should be made in the right proportion over the different crops. In stock farming, the proper balance must be maintained between crops for feed and animals to be fed. Attention should be given to the quality as well as to the quantity of production. This refers to the improvement of both plants and animals. Good plants and good animals are always more profitable than poor ones. The control of plant diseases, weeds and insects should be included as part of the system where crops are produced.

The principles underlying the various factors involved in farm planning and organization have been presented in the preceding chapters. These principles must be kept in mind in working out the details of any system.

System of accounting. — As a basis for successful organization and management some record of transactions involving receipts and expenditures must be kept. Other kinds of business much less complex than the business of farming

require detailed records of this sort. Every farmer, as manager of his own farm, should employ some system of accounting that will not only keep him informed as to his total profits or losses for the year, but also as to such details as the cost of, and the return on, various phases of his business, such as individual crops, groups of farm animals, etc. It should tell him whether or not his cows are paying for their board; how much his horses are costing him; and whether his wheat is more profitable than some other crop, such as barley, oats, etc.

Requirements of a system of farm accounting.— The farmer must usually be his own bookkeeper. For this reason, the system he is to use should be simple enough to require but little of his time. At the same time it must be accurate and complete enough to keep him informed in regard to the essentials of his business.

The following records will usually prove adequate for a complete system of farm accounting: inventory; cash received and paid out, in totals and classified; bills owed to others or bills payable; bills others owe him or bills receivable; labor records, including horses and men; feed records; production records. The first two in this list are absolutely essential to give him a correct interpretation of the farm business. The others are useful in locating profitable and unprofitable enterprises.

Inventory.— An inventory is simply a list, giving values of everything connected with the farm business. It should be taken at least once a year, usually just before the planting season begins, in order to show how much has been made or lost during the previous year. This refers only to the farm as a whole. It does not tell what particular enterprise is the most or least profitable. To secure this information

special records like feed, labor and production records, are necessary.

The inventory should include every item and its value in connection with the farm business. Such materials as feed should be weighed or measured to secure accuracy. In practice, the entire farm may be gone over systematically and the various items listed. The items on this list may then be classified and entered on the inventory sheet, and the value of each written in. The inventory is complete when all the items are entered and the sum of their values determined. The essential features of an inventory are indicated in the following example:

INVENTORY	1918	1919
Real estate (farm, etc.)	\$14,000.00	\$14,000.00
Cattle:		
Dairy	600.00	600.00
Beef	2,000.00	2,200.00
Horses	1,200.00	1,180.00
Hogs	600.00	770.00
Poultry	50.00	75.00
Machinery and tools	700.00	675.00
Feed	900.00	1,100.00
Seed	100.00	150.00
Other supplies	75.00	60.00
Cash	300.00	250.00
Bills receivable	500.00	1,200.00
Total investment	\$21,025.00	\$22,260.00
Bills payable (deduct)	400.00	
	<u>\$20,625.00</u>	<u>\$22,260.00</u>
Increase (profits)	1,635.00	
	<u>\$22,260.00</u>	<u>\$22,260.00</u>

Cash record. — This should include all receipts and expenditures. When money is received or expended, the amount

should be entered promptly so as to avoid oversight. The best system of cash accounting is one in which two entries are made of each cash transaction: one in the column for totals; the other in a column provided for the enterprise concerned. For example, if \$50 is received for a load of corn, the amount, \$50, will be entered in the first or total column, and also in the column devoted to corn.

There are two kinds of cash records. They are arranged in exactly the same way. One is devoted to entries of money received and the other to money paid out. At regular intervals, once a week or once a month, footings should be made of totals and of each farm enterprise included in the cash record. The sum of all the cash items entered in the various columns devoted to farm enterprises should exactly correspond to the sum of the total column. One serves as a check on the other. If they do not correspond, some mistake or oversight is indicated. The difference between the total sum expended and the total sum received is the cash balance. The difference between the two entries, amount received and amount spent of a single enterprise, will indicate how the enterprise is going, whether at a profit or a loss.

But in order to determine more accurately the gain or loss of a particular enterprise, other records are necessary. These records show values other than cash received or paid out. For example, corn as an enterprise, should be charged with labor and credited with the feed furnished to the live stock. When all values including cash are charged against, or credited to, an enterprise, the difference between the two totals will be the gain or loss of that enterprise.

Records of this kind may be kept for the most important enterprises. They will comprise two sets of entries, one for receipts and the other for expenditures. The receipts or

1919

CASH PAID

Date	Item	Total	Cattle	Hogs	Horses	Poultry	General	Labor	Ma- chinery	Farm	Corn	Etc.
Jan. 10	Telephone, 3 mos.	6.00					6.00					
" 15	Horse shoeing	3.00			3.00							
" 23	Corn, 50 bu.	75.00	25.00	50.00								
" 31	Farm hand	40.00						40.00				
		124.00	25.00	50.00	3.00		6.00	40.00				

CASH RECEIVED

Date	Item	Total	Cattle	Hogs	Horses	Poultry	General	Labor	Ma- chinery	Farm	Corn	Etc.
Jan. 5	Butter fat, 90 lbs. @ .50	45.00	45.00									
" 6	Eggs, 10 doz. @ .60	6.00				6.00						
" 12	Butter fat, 80 lbs. @ .55	44.00	44.00									
" 13	Eggs, 6 doz. @ .65	3.90				3.90						
" 20	Butter fat, 100 lbs. @ .55	55.00	55.00									
" 21	Eggs, 4 doz. @ .70	2.80				2.80						
" 29	Butter fat, 85 lbs. @ .50	42.50	42.50									
" 30	Calf, 1	20.00	20.00									
		219.20	206.50			12.70						

credits will include all products sold, an inventory of amount on hand at end of year, the amount used for feed or saved for seed, residue of manure and fertilizer, which may be estimated as remaining for the next crop.

Special farm record and account books have been prepared by the U.S. Department of Agriculture and by various State Agricultural Colleges. Those interested in keeping farm records should secure a copy of an approved record book.

The expenditures or charges will include an inventory of the amount of the crop on hand from previous year, manure and fertilizer from the preceding crop, manure and fertilizer applied to present crop, seed (if bought), and man and horse labor. For an accurate and complete cost account of an enterprise such items as the use of buildings, land, etc., and interest on all costs relating to the enterprise should be charged. The following example will show how the entries are made:

	CORN	RECEIPTS	Cr.
Nov. 1	15 T. fodder to cows (a) @ 8.00		120.00
" 15	1000 bu. sold, cash (b) @ 1.20		1200.00
" 30	500 bu. to cows (a) @ 1.20		600.00
Dec. 31	Fertilizer residue (estimated)		40.00
			<u>1960.00</u>

NOTE — a. Should appear also as a charge in acct. with cows.
b. Should appear also in cash acct. as money received.

	CORN	EXPENDITURES	Dr.
Dec. 31	3 T. fertilizer (a) @ 35.00		105.00
	1409 man hrs. (b) @ .35		493.15
	1632 horse hrs. (c) @ .15		244.80
	8 bu. seed (d) @ 5.00		40.00
	Use of land, interest, etc.		<u>300.00</u>
			1182.95

NOTE. — a. Should appear also in cash acct. as money paid out.
b. Should appear also as credit item in labor acct.
c. Should appear also as a credit item in acct. with horses.
d. Carried over from previous crop and might have been charged here as inventory.

Bills payable and bills receivable. — When there are many business transactions that are not on a cash basis, a record of the “bills I owe” and the “bills owed me” should be kept. Whenever a bill is paid, the item in the record should be so marked. The amount should be entered in the cash record at the same time. The following examples will show the details of making these records:

What I owe — BILLS PAYABLE

Date	Due	Paid	Person	Amount	Description
Jan. 1	Apr. 1		Bank	1000.00	To buy cattle, 6%
Feb. 2	2 yrs.		J. Jones	1500.00	10 A. land, 6%

What others owe me — BILLS RECEIVABLE

Date	Due	Paid	Person	Amount	Description
Jan. 1	Mar. 1		L. Smith	1500.00	Cattle sold, 6%
“ 15	“ 15		J. Henry	150.00	1 cow, no int.

Labor records. — If the amount of gain or loss in a particular enterprise is to be determined, a labor record must be kept, so that the enterprise may be charged with the labor expended upon it. The following is a convenient form of labor record:

LABOR RECORD — CORN

Date	Operation	Man hrs.	Horse hrs.	Tractor hrs.
Apr. 1	Plowing: corn, 30 A.; field, 3-horse plow	9	27	
“ 2	“ “ “ “ “ “	8	24	
“ 3	“ “ “ “ “ “	6	18	

FEED RECORD

[illegible]

Production record.— Since the value of an animal is largely determined by its production, a record of this production will indicate just how valuable the animal may be. These records are especially valuable in milk and egg production, for they may show what individuals to keep and what ones to weed out, making it possible to improve the herd or flock. The production record for milk is a good

illustration. Milk-record sheets may be obtained from a State Agricultural College or State Experiment Station. One may be prepared by ruling a large sheet of strong paper as indicated in figure of record sheet reproduced on page 237.

CHAPTER XXIX

THE FARM HOME

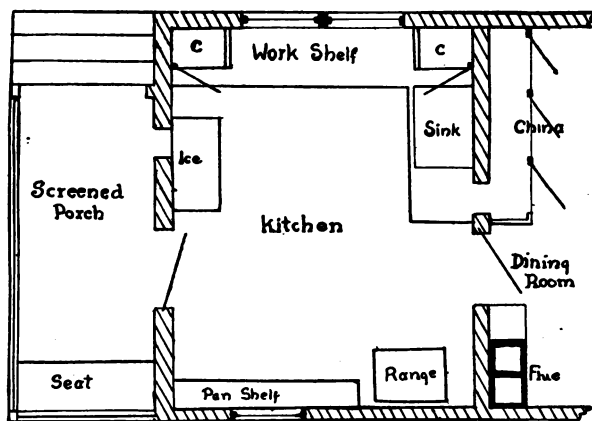
Living conditions. — The farm is not merely a place on which to make a living. It is, at the same time, a place where the farmer and his family live — their home. Aside from the personal family life that fixes the character of the home, there are several material essentials, such as conveniences and comforts, that affect the lives of the family, particularly of the women. The farmer's home should possess many of the advantages enjoyed in a city or town home. It should be convenient, comfortable, sanitary, and attractive. Farmers are sometimes tempted to move to a city or town to get these things when they may be secured right on the farm. It has been estimated that an expenditure of the price of a city lot would make a farm home equal in attractiveness to a home in the city. In fact this has been done on many farms.

Conveniences. — In the last chapter, attention was called to the value of time. This applies quite as well to the farmer's wife as it does to him or to the help he hires. Home conveniences have to do with various kinds of equipment that save steps and time and make the burden of housekeeping easier. This includes arrangement of rooms in the house, running water, bathroom and toilet, and especially a kitchen with labor-saving devices.

A rearrangement of the rooms of a house may not always

be possible. But usually some changes may be made that will make the house more convenient. If a new house is to be built, there will be no difficulty about a convenient arrangement.

Running water for kitchen and bathroom may be provided without great expense by the use of a pressure tank located in the basement of the house. The equipment for a water



Floor plan of well-arranged kitchen. (Adapted from circular of Minnesota Agricultural Experiment Station.)

system consists essentially of a large, galvanized iron tank connected with the well or cistern by pipes, and a force pump. In the absence of a bathroom, sufficient water for use in the kitchen may be provided by using a smaller tank installed above the sink; or a small pump with a cistern connection may be installed at the side of the sink. If there is a supply of running water, a kitchen sink is possible, a feature that is considered necessary in the kitchen of a city home.

A good range, a kitchen cabinet, built-in cupboard, and

a convenient arrangement of the entire equipment of the kitchen will relieve the housekeeper of many of her burdens. The farmer himself has all the labor-saving machinery and equipment he can secure. He is entirely justified in this, but the same reasons also justify providing his home with labor-saving devices and equipment. It is as important to save time and energy in the home as in the fields.

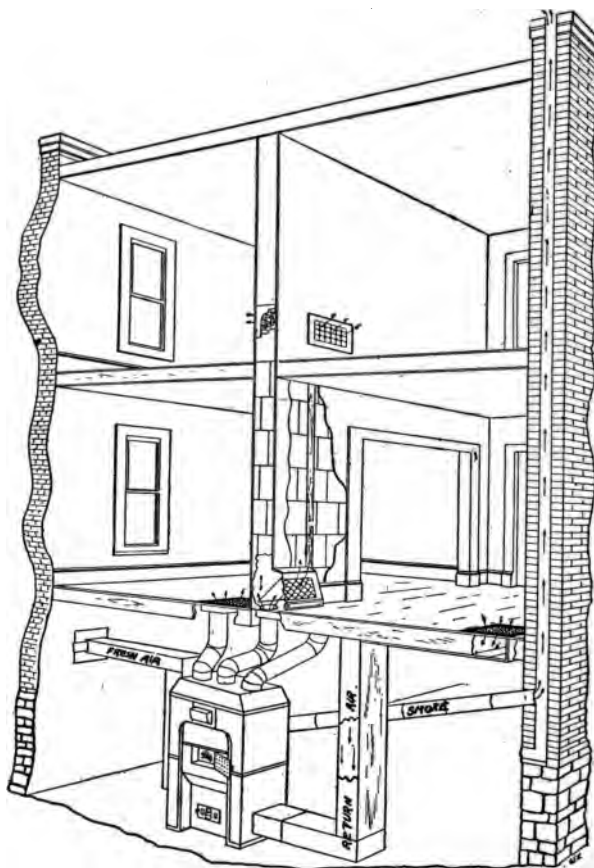
Comforts. — A home is not only a place in which to live but also one to enjoy. A comfortable home does not need to be one of luxury or of elegance. Simple furnishing in good taste gives the most pleasure and greatest comfort. Space does not permit more than a mention of desirable house furnishings.

Heat, light, and water are the first essentials for a comfortable home. Heating by means of stove, water supplied by an outside well or cistern, and light from kerosene lamps are common in farm homes. Such an arrangement is an improvement over that in pioneer times when the fireplace, the spring, and tallow candles furnished heat, water and light; but it requires much labor that might be saved by supplying still more modern conveniences.

It is generally more expensive and requires more work to heat by stoves than by a furnace, and, at the same time, it is less satisfactory from the standpoint of comfort. A well-installed furnace, distributing the heat uniformly through the house, removes the discomfort and perhaps the danger of passing from a heated into an unheated room. Besides uniformity in heating, good ventilation may be secured at the same time by furnace heating.

Lighting by means of lamps, while fairly satisfactory, causes much labor in the care of the lamps. Acetylene gas or electricity may now be installed in a farm home at a reason-

able initial expense. Afterwards the cost of lighting is slight and the labor a trifle. An electric lighting system may be

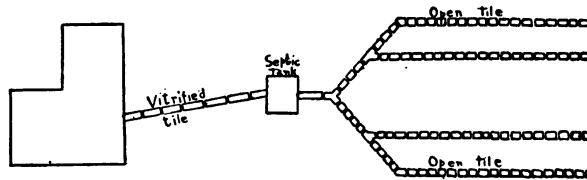


Heating by means of hot-air furnace.
(Minnesota Agricultural Experiment Station.)

extended to the barn and other buildings, used also to furnish power for pumping water, separating milk, running the

washing machine, iron, sewing machine, sweeper and other purposes.

The need of running water for the kitchen has already been mentioned. When a house in a town or city is said to



Plan showing connection of house drain with septic tank and provision for overflow from septic tank into a system of open drains.

have modern improvements, a bathroom and indoor toilet are generally referred to. Houses thus equipped are always in greater demand and command a higher rental than others. It is not a difficult matter to provide these in a farm home. Running water and a means for disposal of wastes are necessary. The same system that furnishes water and carries away the wastes from the kitchen may be used for the bathroom and toilet. A water heater may be attached either to the kitchen range or to the furnace and will supply water not only for the bathtub and wash basin, but also for the kitchen.

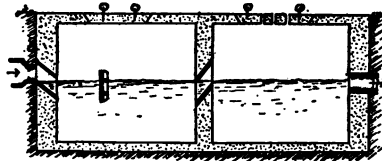
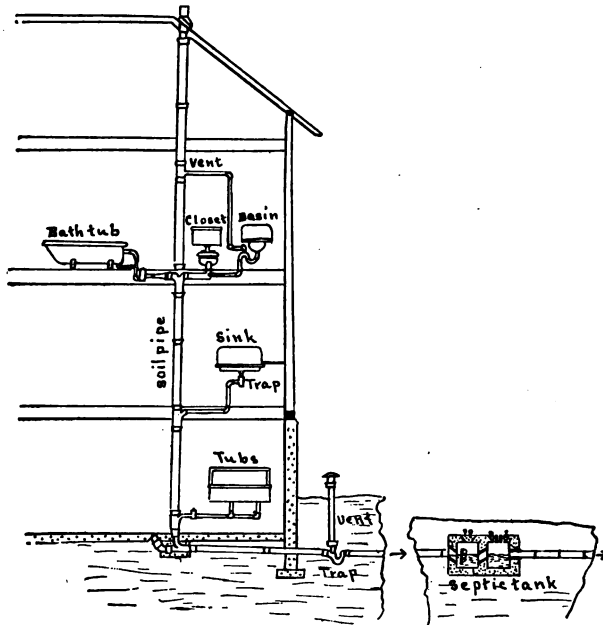


Diagram of concrete septic tank for disposal of sewage from a farm home.

Sanitation. — A house should not only be convenient and comfortable, but it should be a healthful place in which to live. It is well known that many diseases are induced by

germs or bacteria. True cleanliness is the kind that removes most of the danger of disease from germs.

Source of infection is not a pleasant subject to consider, but it is one on which every one should be informed. Contamination from the wastes of the human body is a most



Plan of installation of complete system for disposal of household wastes. Distance of septic tank from house should be at least fifty feet. (Cornell Agricultural Experiment Station.)

common source of disease. The custom of placing outdoor toilets near wells is a dangerous one. The origin of many cases of typhoid fever has been traced to wells into which wastes have entered from toilets.

One of the best ways to dispose of these wastes, as well as of those from the kitchen, is by the use of a septic tank. Sewage disposal by this means is based upon the action of bacteria on the organic matter which always forms a considerable part of household wastes. A simple form of septic tank consists of two water-tight, underground chambers; the first to retain solid matter and scum until they are dissolved, the second to receive liquids from the first chamber and discharge them at intervals by means of a siphon.

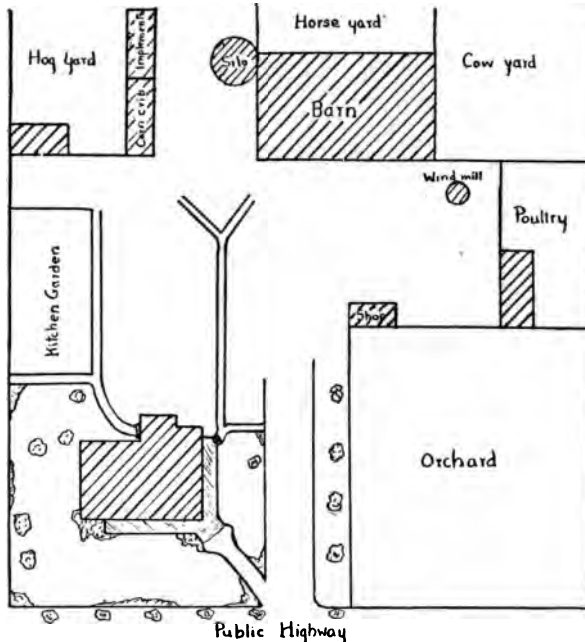
A complete outfit including cement tank, vitrified tile set with closed joints to convey material to the tank, and porous tile set with open joints to conduct the liquids away from the tank, may be installed at a moderate cost.

Making the home attractive.—A home should afford pleasure to its occupants. First of all, as already considered, it should be made comfortable in such essentials as heat, light, and water. Next, it should be made attractive, both as to the house and its setting and the interior and furnishings of the house.

The site of the farm home is often selected solely because of its convenience. Although convenience, with respect to accessibility to the farm and to the public highway, is important, the healthfulness and attractiveness of the site should receive equal consideration. For sanitary reasons the building site should first of all be well drained. Situations somewhat higher than surrounding areas are better drained than those that are low or level. Such a situation also makes an attractive setting for the home. It enables the house and its surroundings to stand out prominently and affords distant views, revealing whatever beauty there may be in the surrounding landscape.

A well-chosen site is only one part of the setting of the

farm home. The arrangement of the farm buildings, the placing of the house, and the presence of lawn, trees, shrubs, and flowers all contribute to the setting. The farm buildings should be accessible and so placed as to save steps, but they should be in the background, so that they may be screened



A plan of a farmstead illustrating some features suggested in the text.

from undue prominence by means of trees and shrubs. Since the farm orchard and garden to be accessible must be near the yard, they may be considered as part of the setting of the house. Careful attention should be given to location of walks, a matter often neglected around farm homes. All parts of the farmstead in frequent use, especially those near

the house, should be made easily accessible by means of convenient walks.

The yard is perhaps the most important single feature of an attractive setting for a house. The house becomes the center of the picture; the lawn, trees, shrubs and flowers form the background and frame of the yard. In making such plans effective, three fundamental rules of landscape gardening should be applied: avoid straight lines; leave open spaces; plant shrubs and trees in irregular masses.

A home, to be attractive, need not be one of luxury or of elegance. Simple furnishings that show good taste and are well arranged give the most pleasure and the greatest comfort. Three easily applied principles need to be observed in furnishing and arranging furniture in the rooms of a home.

First, each room will have some predominating feature, such as a fireplace, a rug, or piece of furniture that may be regarded as the center of interest. The rest of the furnishings should be subordinated to this feature. For example, if the fireplace is the center of interest, the furnishings should be so grouped and subordinated as to add to the pleasing effects of this feature.

Second, there should be symmetry or balance in placing the furnishings. For example, in a living room the fireplace with a picture above the mantle may be balanced by having a davenport, or davenport and table placed opposite. A large piece of furniture may be balanced by two smaller pieces.

Third, angles formed by one piece of furniture with another should be avoided as much as possible. The placing should be guided by the lines of the room. For example, a piece of furniture set across the corner of a room gives a less pleasing effect than if placed in a line with the wall.

These three principles relate to effective placing and grouping of furnishings. The living room is used merely as an example to illustrate the application of these principles. They may be applied to other rooms as well. They also apply, with slight modification, to the placing and hanging of pictures.

Color combinations should also receive consideration. This refers to floors, woodwork and walls as well as to the furnishings. In general, the proper color combinations, or values, should present a gradual transition from the floor to the ceiling; the floor should be the darkest, next, the walls and the ceiling, the lightest. For example, a light floor and a dark rug would make an unpleasant contrast. On the other hand, if the floor is stained or painted so as to correspond to the depth of color of the rug, the two will present a pleasing uniformity.

CHAPTER XXX

THE RURAL COMMUNITY

THE farmer's first concern must be to make a living, so most of the preceding pages have been devoted to that aspect of farm life which has to do with agriculture in its various phases. But the farmer must have a place in which to live — a home, and it should be the best home he can afford. Some of the essentials of a comfortable farm home with special reference to ease in housekeeping were considered in the last chapter. Finally, the farmer must live among other people with whom he has interests in common. He has neighbors and should have friends and companions. It seems worthwhile, therefore, to conclude the book with a chapter devoted to the farmer and his relation to others of the community.

The particular problem of each individual of a rural community is to make the most of the relations with others, both for the sake of himself and his family and of those with whom he may become associated. Moreover, mere participation in community affairs, while infinitely better than selfish isolation, is not enough. Each individual should coöperate with others to make his community or neighborhood a better place in which to live. Coöperation means getting together; living to himself, an individual is apt to be narrow and one-sided in his views; in a group, he tends to become broader minded and to forget his prejudices in a wider interest. Singly, an individual's information generally

comes to him in fragments, often from a faction that presents but half the truth; collectively, or in a group for discussion, each one may hear all sides — all the facts. Country people need occasions for getting together where affairs of common interest may be discussed and acted upon.

To be effective this coöperative interest must take into consideration first, things as they are; second, as they should be; third, how they might be changed for the better.

Though many undesirable conditions in a rural community may be recognized generally, they are often accepted as a matter of course. Nearly every one may know, for example, that some roads are very good and that some are very poor; that the school is lacking in many things actually needed; that the influence of the church is less than it should be; that the opportunities for social life are meager; that means for recreation are wanting. If a survey of the conditions in any community or neighborhood shows defects, two courses are open — to let conditions remain as they are, or to take steps to improve them. But if improvements are to be made there must be some ideal as to what they should be and how they will enrich the lives affected by them. Here the experience of other communities that have solved similar problems may be drawn upon. Finally, there must be coöperative effort, following a definite program agreed upon by all concerned, to bring about the change. The value of such an improvement, however important it may be in itself, is not less than the benefit that comes to the people of the community who meet together to discuss their common problems and work together to solve them. They will come to know one another better, to have more regard for one another, and will gain the valuable experience necessary for the success of other coöperative enterprises.

The relation of the farmer to others of the community includes the following fields of activity: business, education, religion, social affairs, recreation. Rural people, and others too, find a common interest in each of these activities and they require coöperative effort to be of value to the community.

Business relations. — This group refers to any kind of coöperation among farmers for conducting enterprises concerned with the business of farming. It includes such simple forms of coöperation as exchange of labor, such as filling silos, threshing grain, and the like. It also includes larger enterprises requiring complete and permanent organization, such as coöperative creameries, fruit exchanges and live-stock associations.

All forms of coöperation between, and including, these extremes are based upon the principle that a number of individuals working as a group, wisely directed, may accomplish more than the same number with each one working independently.

The advantage of coöperative effort is being recognized by farmers. This is indicated by the fact that in the last thirty years coöperative societies have increased from a few thousand to more than one hundred thousand. These figures include only the larger societies. The following examples will illustrate the nature and importance of the larger organizations: Live-stock shipping associations have been maintained successfully in several states of the Middle West. By means of these associations, farmers are able to ship, advantageously, less than car-load lots of live stock directly to the market and receive a profit that would otherwise go to a local live-stock buyer.

Coöperative grain elevators are another example. In

Minnesota, in 1916, 270 of these elevators did a business of about \$24,000,000. In addition to handling grain, most elevator associations make coöperative purchases of supplies, such as coal, feed, binder twine, etc.

Real coöperation, in the sense of loyalty of members to each other and to the coöperative concern, and good management are necessary for success. The gains made by a small, but well-managed enterprise, engaged in jointly by a number of farmers in any neighborhood, may make the undertaking quite worthwhile; but the experience of working together will be worth even more than the profit in dollars and cents. It will also encourage the undertaking of larger enterprises.

The thing most lacking in securing coöperative effort among farmers is leadership. This is now supplied in many localities by the county farm agent. While he cannot enter actively into any coöperative organization, he is able to give much assistance in getting it under way.

Educational relations. — The need of educational opportunities is recognized in most communities. The standards may not always be high, but there is generally a genuine desire to give the children the benefit of such educational advantages as the school may afford. The school therefore becomes a center of common interest. With this interest as a basis, school patrons may be brought together to deal with matters affecting the school; for example, to make a campaign for better financial support. Organizations composed of teachers and parents, such as patrons' clubs and mothers' clubs, may not only initiate movements for better facilities, but will give the teachers the support and encouragement necessary for the best service.

The school itself should extend its influence beyond its four walls into the homes of the community. Much of the

regular school work may be made to relate itself to the problems of the farm and home. Many country schools now include in their work such assistance to patrons as corn-germination tests, Babcock tests for butter fat, fertilizer estimates, milk records, and home projects, such as canning, garment making, gardening and similar activities.

We have here a suggestion well worthwhile: The parents and others in the community should coöperate with one another and with the teacher for the best interest of the pupils; and the pupils should coöperate in their school work or under the direction of the teacher in helping solve some of the problems that arise on the farm and in the homes.

Church relations. — Little need be said of the importance of church relations, except to point out the desirability of making the most of them. The church affords an opportunity for landowner, tenant and hired help to meet on a common basis. It already has its organization and leader, the pastor. It also has for its guidance the highest ideals of fellowship and coöperation. But the organization, leadership, and ideals must affect the community through the church members. This means more than mere belief in the church or attendance only. It means active participation, not only in church matters but in all that pertains to the welfare of the community.

Social relations. — In general, social relations include the various forms of intercourse where individuals meet one another. They may be casual, as on the road, in the store, or at church. Even a business transaction may have in it elements of a social nature. In these examples the social features are more or less incidental.

There are other ways in which people come into contact with one another where enjoyment of fellowship predominates,

as in church socials, farmers' clubs, school entertainments picnics and the like.

The very nature of farm life tends toward isolation. Homes are far apart. Farm work itself deals with nature rather than people. There are few occasions or opportunities for extended acquaintance with people. Rural life is especially lacking in adequate social interests for boys and girls who are passing from childhood to maturity. Yet contact with others is quite as important for the farmer and his family as it is for the city dweller and his family. Human intercourse — making acquaintances and friends — is too valuable an experience to be left out of life.

How to secure adequate social life is a difficult problem for most rural communities. A partial solution has already been suggested. It lies in the fullest coöperation and in the use of all existing agencies, such as business organizations, schools, churches, clubs and the like, to furnish occasions for social intercourse. The value of having an occasion for getting together is well illustrated by the influence of the Red Cross Society. During the Great War branches of this society were organized in most rural communities. People came together who never before had found a common interest. The members did a fine, patriotic service, but they also learned how to work in harmony and to know and appreciate each other; they made the beginnings of real friendship.

One of the best agencies for the promotion of social life in rural communities is the farmers' club. In general, its object is to promote the interests of the community whenever there may be need for united action. The meetings are occasions for getting acquainted and encouraging sociability, as well as for purposeful activity.

Recreation. — The need of wholesome recreation, es-

pecially for children and young people, has been very generally recognized in cities. Playgrounds and recreation centers for both children and adults are organized in most cities and are rendering a splendid service.

One of the lessons of the Great War is that of emphasizing the importance of recreation. An outstanding feature of the cantonments where many thousands of soldiers were trained was the provision for recreation. Perhaps no other one thing, aside from actual military training itself, contributed so largely to the efficiency of our soldiers as participation in the various forms of recreation afforded at the camps.

It is hardly necessary to point out the value of recreation for people who live on farms. Play and relaxation are just as much needed by them as by other people.

Fortunately, it is now possible in most rural communities to develop organized recreation. There are several agencies through which it may be developed, such as the school, the church and Sunday school, the rural Y. M. C. A., the Boy Scouts and the Campfire Girls, clubs, and social organizations.

Recreational activities that have been successful in rural communities may be included in four groups: first, those that are suggested by the open country itself, such as fishing, camping, tramping, winter sports, coöperative farm work, such as husking bees, etc.; second, those furnished by the school, church, and such organizations as the Boy Scouts, Campfire Girls, and rural Y. M. C. A.; third, playground activities with supervised play, games and athletics; fourth, community activities such as festivals, pageants, athletic field-days, play-picnics, and the like.

Leadership and full participation are necessary for success in any of these activities. Arrangements must be made for

individuals of all ages to take part. The teacher and pupils of a rural school could easily undertake to initiate recreational activities in any community. Details and plans for introducing various forms of recreation may be obtained from the Extension Department of the State Agricultural College; the State Secretary of Rural Y. M. C. A.; the State Office of Public Instruction; the Country Life Commission of the Federal Council of the Churches of Christ in America, New York City; and from the Playground and Recreation Association of America, Metropolitan Building, New York City.

APPENDIX

PART I

REFERENCES

The following list of references will supplement the various phases of subject matter presented in the text. As many of them as possible should be in the school library for the use of teacher and pupils.

The pamphlets may be obtained, with few exceptions, free of cost. Requests for publications of the United States Department of Agriculture should be addressed to the Secretary of Agriculture, Washington, D.C. It is not necessary to write the title in the request but it is important to give the number of the bulletin or circular and the class to which it belongs, for example, Farmers' Bulletin, No. 77; Yearbook Separate, No. 637; Department Bulletin, No. 78.

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Meadows for the Northern States. No. 1170
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Late or Main Crop Potatoes. No. 1064
Home Supplies Furnished by the Farm. No. 1082
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Producing Family and Farm Supplies on the Cotton Farm. No. 1015
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PART II

Digestible Nutrients in 100 Pounds of Common Feeding Stuffs

KIND OF FEED	Dry Matter	Digestible Nutrients		
		Crude Protein	Carbo- hydrate	Fat
<i>Roughage</i>				
Corn fodder with ears on.	57.8	2.5	34.6	1.2
Corn fodder, ears removed.	59.5	1.4	31.2	0.7
Corn silage.	26.4	1.4	14.2	0.7
Hay from mixed grasses.	84.7	4.2	42.0	1.3
Kentucky blue grass.	86.0	4.4	40.2	0.7
Red clover.	84.7	7.1	37.8	1.8
Soybean hay.	88.2	10.6	40.9	1.2
Cowpea hay.	89.5	9.2	39.3	1.3
Alfalfa.	91.9	10.5	40.5	0.9
Hairy vetch.	88.7	11.9	40.7	1.6
Velvet bean.	90.0	9.6	52.5	1.4
Mixed grasses and clover.	87.1	5.8	41.8	1.3
<i>Concentrates</i>				
Dent corn.	89.4	7.8	66.8	4.3
Flint corn.	88.7	8.0	66.2	4.3
Corn meal.	85.0	6.1	64.3	3.5
Corn and cob meal.	84.9	4.4	60.0	2.9
Gluten feed.	90.8	21.3	52.8	2.9
Gluten meal.	90.5	29.7	42.5	6.1
Standard wheat middlings (shorts)	88.8	13.0	45.7	4.5
Wheat bran.	88.1	11.9	42.0	2.5
Wheat screenings.	88.4	9.6	48.2	1.9
Rye.	91.3	9.5	69.4	1.2
Barley.	89.2	8.4	65.3	1.6
Oats.	89.6	8.8	49.2	4.3
Ground oats.	88.0	10.1	52.5	3.7
Oat middlings.	91.2	13.1	57.7	6.5
Cowpea.	85.4	16.8	54.9	1.1
Soybean.	88.3	29.1	23.3	14.6
Kafir corn.	90.1	5.2	44.3	1.4
Linseed meal (old process).	90.2	30.2	32.0	6.9
Linseed meal (new process).	91.0	31.5	35.7	2.4
Cotton seed.	89.7	12.5	30.0	17.3
Cotton seed meal.	93.0	37.6	21.4	9.6
Cotton seed hulls.	88.9	0.3	33.2	1.7
Dried brewers' grains.	91.3	20.0	32.2	6.0
Dried distillers' grains.	92.4	32.8	39.7	11.6
Dried beet pulp.	91.6	4.1	64.9
Sugar beet molasses.	79.2	4.7	54.1

PART III **FEEDING STANDARDS**

DAILY REQUIREMENTS FOR 1000 POUNDS LIVE WEIGHT

(Adapted from Henry's Feeds and Feeding)

	Dry Matter	Digestible			Nutri- tive ratio
		Protein	Carbohydrates and fat (x 2.25)	Total	
	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	<i>Pounds</i>	
Horses, lightly worked. . . .	20	1.5	10.4	11.9	1:6.9
Horses, moderately worked	24	2.0	12.4	14.4	1:6.2
Horses, heavily worked. . .	26	2.5	15.1	17.6	1:6.0
Cattle, fattening, first period.	30	2.5	16.1	18.6	1:6.4
Cattle, fattening, second period.	30	3.0	16.1	19.1	1:5.4
Cattle, fattening, finishing period.	26	2.7	16.6	19.3	1:6.1
Sheep, coarse wool.	20	1.2	11.0	12.2	1:9.2
Sheep, fine wool.	23	1.5	12.7	14.2	1:8.5
Ewes with lambs.	25	2.9	16.1	19.0	1:5.6
Sheep, fattening, first period.	30	3.0	16.1	19.1	1:5.4
Sheep, fattening, second period.	28	3.5	15.9	19.4	1:4.5
Brood sows.	22	2.5	16.4	18.9	1:6.6
Hogs, fattening, first period	36	4.5	26.6	31.6	1:5.9
Hogs, fattening, second period.	32	4.0	25.1	29.1	1:6.3
Hogs, fattening, finishing period.	25	2.7	18.9	21.6	1:6.3

PART IV
SPRAYING PROGRAM
(From Ohio State Agricultural Experiment Station. Although prepared
for Ohio this program has very general application)

APPLE

Spray No.	When to Apply	Materials to Use	What For
1.....	When leaf buds show green before leaves appear.....	Lime-sulphur (33° Beaume) — 1 part Water — 7 parts Or — Miscible oil — 1 part Water — 15 parts Or — Powdered lime-sulphur, 15 pounds in 50 gallons of water Or — Soluble sulphur 12½ pounds to 50 gallons of water.....	Scale Aphis eggs Mites eggs
2.....	When cluster buds show pink before blossoms open.....	Bordeaux mixture (3-5-50), if canker worms (measuring worms) are present add arsenate of lead 1½ pounds powder (2½ paste) to 50 gallons of spray. If aphids are numerous add nicotine sulphate 1 pint to 100 gallons of spray.....	Black rot Apple scab Canker worms Aphis
3.....	Just after petals fall.....	Lime-sulphur 1½ gallons plus arsenate of lead 1 pound powder (2 pounds paste) to 50 gallons of water. If aphids are numerous add nicotine sulphate 1 pint to 100 gallons of spray.....	Aphis Apple scab Sooty fungus Curculio Codling moth Canker worms
4.....	14 days after spray No. 3...	Bordeaux mixture (3-5-50) for blotch Or — If blotch is not present, lime-sulphur 1½ gallons plus arsenate of lead 1 pound powder (2 pounds paste) to 50 gallons of water. Use Bordeaux mixture instead of lime-sulphur on Ben Davis, Gano, Smith Cider, Mann, Rome Beauty, Missouri Pippin, Red Astrachan, Maiden Blush, York Imperial, Oldenburg, Stark and N. W. Greening varieties, all these being specially susceptible to blotch.....	Apple blotch Codling moth Curculio
* Special blotch sprays.	2 weeks after spray No. 4 if blotch is serious. Again 4 weeks after spray No. 4 (6 weeks after petals fall) if blotch is very serious.....	Bordeaux mixture (3-5-50).....	Blotch
5.....	9-10 weeks after spray No. 3 (July 1 to 20)...	Bordeaux mixture (3-5-50) plus arsenate of lead 1 pound powder (2 pounds paste) to 50 gallons of water.....	Black rot Bitter rot Apple blotch Codling moth

* Special sprays are not numbered as they are not part of the customary program but are supplementary sprays for emergency conditions.

PEAR AND QUINCE

Spray No.	When to Apply	Materials to Use	What For
1.....	When leaf buds show green before leaves appear.....	Or — Lime-sulphur liquid — 1 part Water — 7 parts Or — Miscible oil — 1 part Water — 15 parts Or — Powdered lime-sulphur, 15 pounds in 50 gallons of water.....	Scale Aphis eggs Mites eggs Scab
2.....	Soon as petals fall.....	Lime-sulphur liquid $1\frac{1}{2}$ gallons, water 50 gallons, plus arsenate of lead powder 1 pound (2 pounds paste) Or — Bordeaux mixture (3-5-50) plus arsenate of lead powder, 1 pound (2 pounds paste) Or — Lime-sulphur powder 2 pounds in 50 gallons water, plus arsenate of lead powder 1 pound (2 pounds paste).....	Codling moth Pear slug Scab Sooty fungus Leaf-spot
3.....	9 to 10 weeks after No. 2 (July 15-August 1).....	Lime-sulphur $1\frac{1}{2}$ gallons, plus arsenate of lead powder 1 pound (2 pounds paste) to 50 gallons of water. Or — Bordeaux mixture (3-5-50) plus arsenate of lead powder 1 pound (2 pounds paste) to 50 gallons of water.....	Second brood codling worm Scab Leaf-spot

PEACH

Spray No.	When to Apply	Materials to Use	What For
1.....	In fall after leaves drop, on favorable winter days above 50° F. in February or March or any time before the buds begin to swell. After buds are swollen it is too late to control leaf curl..	Lime-sulphur solution 1 part, water 7 parts Or — Home-boiled lime-sulphur (15-15-50) Or — Powder lime-sulphur 15 pounds to 50 gallons Or — Soluble sulphur $1\frac{1}{2}$ pounds to 50 gallons	Scale insects Peach leaf curl
2.....	After bloom has fallen when husks on young fruit are shedding.....	Self-boiled lime-sulphur (8-8-50) plus $1\frac{1}{2}$ pounds arsenate of lead powder ($2\frac{1}{2}$ pounds paste) in each 50 gallons of spray.....	Curculio Scab Brown rot
3.....	2 weeks after spray No. 2...	(Same as No. 2).....	(Same as No. 2)
4.....	3 weeks after spray No. 3...	Self-boiled lime-sulphur (8-8-50).....	Brown rot Scab
5.....	3 to 4 weeks after spray No. 4 on late varieties if brown rot is prevalent.....	(Same as No. 4).....	Brown rot

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PLUM

Spray No.	When to Apply	Materials to Use	What For
1.....	In late fall after leaves have fallen, on favorable winter days above 50° F. in Feb. or March, or in spring before leaves appear...	Lime-sulphur solution 1 part, water 7 parts Or — Home-boiled lime-sulphur (5° Beaume) Or — Miscible oil 1 part, water 15 parts Or — Powdered lime-sulphur, 15 pounds to 50 gallons Or — Soluble sulphur, 12½ pounds to 50 gallons.	Scale insects
2.....	When bloom has fallen and husks are pushing off young fruit.....	On American and Japanese varieties — Self-boiled lime-sulphur (8-8-50) plus arsenate of lead powder 1½ pounds (2½ pounds paste) Or — On European varieties and hybrids — Commercial lime-sulphur 1 gallon to 50 gallons of water plus arsenate of lead powder 1½ pounds (2½ pounds paste) Or — If curculio is serious, use Bordeaux mixture (3-5-50) plus 2 pounds arsenate of lead powder (4 pounds paste) and add 2 pounds of dissolved soap to each 50 gallons of spray as a sticker.....	Curculio Brown rot
3.....	2 to 3 weeks after spray No. 2...	(Same as No. 2).....	Curculio Brown rot
4.....	4 to 5 weeks after spray No. 2.....	Same as No. 2, preferring self-boiled lime-sulphur (8-8-50) plus arsenate of lead powder 1½ pounds (2½ pounds paste).....	Curculio Brown rot

CHERRY

Spray No.	When to Apply	Material to Use	What For
1.....	In fall after leaves drop on favorable winter days when temperature is above 50° F. in February or March or any time before the leaves appear. If scale is not present, the time when the buds are swelling is most favorable to control fungous diseases.....	Lime-sulphur solution, 1 part, water 7 parts Or — Home-boiled lime-sulphur brought to 5° Beaume Or — Miscible oil — 1 part Water — 15 parts Or — Powdered lime-sulphur 15 pounds to 50 gallons of water Or — Soluble sulphur 12½ pounds to 50 gallons of water. If scale is not present spray all varieties with Bordeaux mixture (3-5-50) for brown rot..	Scale insects Brown rot Leaf-spot or shot-hole fungus

CHERRY—*Continued*

Spray No.	When to Apply	Material to Use	What For
2.....	Just after blossoms fall and husks are shedding from young fruit....	On sour varieties concentrated lime-sulphur 1 gallon to 50 of water, or use Bordeaux mixture (3-5-50) and add to whichever is used $1\frac{1}{2}$ pounds arsenate lead powder ($2\frac{1}{2}$ pounds paste). Add nicotine sulphate, 1 pint to 100 gallons of whichever spray is used if aphids are numerous. If curculio is bad, use Bordeaux (3-5-50) and 2 pounds dissolved soap plus 2 pounds arsenate lead powder (4 pounds paste). On sweet cherries self-boiled lime-sulphur (8-8-50) plus arsenate of lead powder $1\frac{1}{2}$ pounds ($2\frac{1}{2}$ pounds paste) to 50 gallons....	Curculio Aphids Cherry slug Leaf-spot or shot-hole fungus Brown rot
3.....	2 to 5 weeks after spray No. 2 when fruit begins to color. Very important application....	Commercial lime-sulphur liquid 1 to 50 for both sweet and sour cherries Or — Self-boiled lime-sulphur (8-8-50) preferred for sweet cherries.....	Curculio Aphids Cherry slug Leaf-spot or shot-hole fungus Brown rot
4.....	After fruit is picked.....	Self-boiled lime-sulphur (8-8-50) plus arsenate of lead powder $1\frac{1}{2}$ pounds (3 pounds paste) if slugs are eating leaves.....	Leaf-spot Slugs

GRAPE

Spray No.	When to Apply	Materials to Use	What For
1.....	10 days before bloom opens...	Bordeaux (3-5-50).....	Mildew Black rot
2.....	3 to 5 days after falling of bloom	Bordeaux (2-3-50) plus arsenate of lead powder $1\frac{1}{2}$ pounds (3 pounds paste) and 1 pound resin soap for sticker in each 50 gallons. Use trailer method and pump pressure of 175 pounds.....	Grape berry worm Grape root worm Mildew Black rot Anthracnose
3.....	When grapes first touch in clusters about 1 month after bloom....	(Same as No. 2).....	(Same as No. 2)
4.....	Omit unless worms are very numerous. Then make application near 20th to 25th of July when eggs are being deposited on skins of fruit.	Arsenate of lead $1\frac{1}{2}$ pounds powder (3 pounds paste) in 50 gallons of water.....	Grape berry worm

For all grape sprays use stone lime if obtainable to avoid injury to foliage. The Bordeaux formula (2-2-50), stone lime being used, leaves the smallest amount of spray adhering to the fruit at harvest.

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CURRANT AND GOOSEBERRY

Spray No.	When to Apply	Materials to Use	What For
1.....	While dormant in fall, winter or spring.....	Any of the standard dormant or scale sprays recommended in these tables for other fruits.....	Scale insects
2.....	When leaves are unfolding.....	Bordeaux (3-5-50).....	Leaf-spot Cane wilt Mildew Anthracnose
3.....	Soon after fruit is set.....	Bordeaux (3-5-50) plus arsenate of lead 1½ pounds of powder (3 pounds paste). If aphids are appearing also add nicotine sulphate, 1 pint to 100 gallons of spray....	Leaf-spot Mildew Currant worms Aphids
4.....	2 weeks after spray No. 3 if worms are present.....	Same as for spray No. 3, or hellebore may be used instead of arsenate of lead.....	(Same as No. 3)
5.....	After fruit is picked.....	Bordeaux (3-5-50).....	Leaf-spot Anthracnose

STRAWBERRY

Spray No.	When to Apply	Materials to Use	What For
1.....	When leaves are about one-half grown, before blooming. If the beds are young, spray 1 week later than the old beds.....	Bordeaux mixture (3-5-50).....	Leaf-spot
2.....	After fruit is picked.....	Mow the vines close to the ground and burn them on a windy day or remove and burn; or spray the new growth with Bordeaux (3-5-50). Drouth following such a burning sometimes prevents a crop the next year...	Leaf-spot

RASPBERRY AND BLACKBERRY

Spray No.	When to Apply	Materials to Use	What For
1.....	When dormant in fall, favorable days in winter or spring.....	Any of the standard scale sprays previously recommended in these tables.....	Scale insects
2.....	When buds are swelling, if pale brown beetle, <i>Byturus unicolor</i> , is present..	Arsenate of lead powder $1\frac{1}{2}$ pounds (3 pounds paste) in 50 gallons of water.....	Raspberry dermestid, <i>Byturus unicolor</i>
3.....	When in bloom..	(Same as No. 2).....	(Same as No. 2)

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